FACULTEIT ECONOMIE
EN BEDRIJFSWETENSCHAPPEN

KU LEUVEN

ESSAYS ON FINANCIAL INTEGRATION AND MONETARY POLICY IN SMALL OPEN ECONOMIES

Proefschrift voorgedragen
tot het behalen van de graad
van Doctor in de
Economische Wetenschappen

door

Mara Pirovano

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A mamma e papà, con immenso amore e gratitudine

Doctoral Commission

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CHAPTER 1
INTRODUCTION

THE SMALL OPEN ECONOMIES OF CENTRAL AND EASTERN EUROPE

1.1 The road to European integration

The official membership, in 2004 and 2007, of 10 countries of Central and Eastern Europe (CEE) in the European Union (EU) marked the culmination of a process of European integration started more than half century earlier. After the two world conflicts that divided Europe in the first half of the XX century, a desire for peace and economic cooperation spread among the main political powers of the Old Continent. In 1951, the sovereigns of six countries (Belgium, France, West Germany, Italy, Luxembourg and Netherlands),

> "[...] Convinced that the contribution which an organised and vital Europe can make to civilisation is indispensable to the maintenance of peaceful relations, recognising that Europe can be built only through practical achievements which will first of all create real solidarity, and through the establishment of common bases for economic development, [...], resolved to substitute for age-old rivalries the merging of their essential interests; to create, by establishing an economic community, the basis for a broader and deeper community among peoples long divided by bloody conflicts; and to lay the foundations for institutions which will give direction to a destiny henceforward shared [...]"[1]

signed the Treaty of Paris instituting the European Coal and Steel Community. Only six years later, the first milestone in the road to European economic integration was set when the same countries signed the Treaty of Rome, giving birth to the

[1] Extrait from the preamble of the Treaty establishing the European Coal and Steel Community, signed in Paris on April 18th, 1951.

European Economic Community (EEC), characterized by the free movement of capital, goods and people. While more countries joined the EEC (Denmark, Ireland and the United Kingdom joined in the 1970s, Greece, Portugal and Spain in the 1980s, Austria, Finland and Sweden in the1990s, Cyprus and Malta in 2004), the Schengen Agreement dismantled national borders in 1985 and the Maastricht Treaty instituted the EU in 1993, paving the way for full monetary integration, which culminated in 1999 with the introduction of the Euro and the creation of the European Monetary Union (EMU). [2]

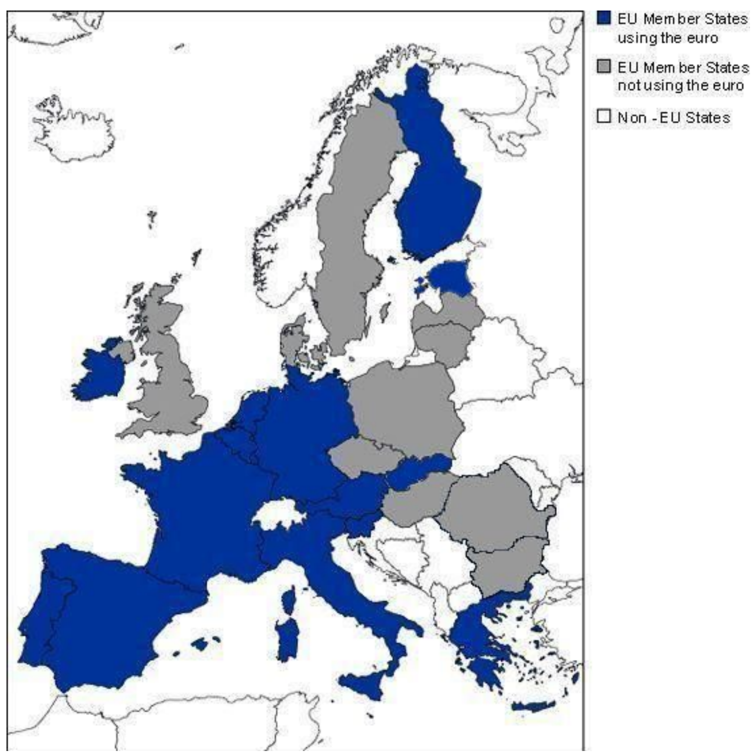
During the first three decades of Western European efforts towards a common path to economic cooperation and development, the Cold War was still ongoing, and countries to the East of the Iron Curtain were subject to communist regimes and policies. The fall of the Berlin Wall in 1989 and the disruption of the Soviet bloc put the Central and Eastern European countries[3] on the path of transition from a centrally planned to a market economy. Creating free markets where they were previously highly regulated entailed a drastic redefinition of the countries' institutions, laws and regulations both within countries and in their international relations. On the domestic side, a massive restructuring involved all areas of the economy, from production to financial sectors. On the international dimension, the transition process led to the dismantlement of economic structures characterized by isolation from the rest of the world, and marked the beginning of an era of increased economic and financial integration between Eastern and Western Europe. The process of economic restructuring was so efficiently managed that, not even two full decades later, the CEE economies

[2] The Euro was initially adopted by 11 countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain). Greece joined the Eurozone in 2001, Slovenia in 2007, Cyprus, Malta and Slovakia in 2008 and Estonia in 2011.

[3] In what follows, I consider in the CEECs group the countries that joined the EU in the two waves of enlargement of 2004 and 2007, namely Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia.

were granted membership in the EU: while the Czech Republic, Estonia, Hungary, Latvia, Lithuania, the Slovak Republic and Slovenia entered in 2004, Bulgaria and Romania followed three years later. The process of integration between Eastern and Western Europe is still ongoing, as full monetary integration with the Euro Area (EA) has been achieved so far only by few formerly transition economies (the Slovak Republic, Slovenia and Estonia), while their fellows intend to join the EMU as soon as they will meet the conditions imposed by the Maastricht Treaty in terms of inflation, exchange rate and government finance.

Figure 1.1: European Union and Euro Area in 2011



While Croatia joined the existing 27 members of the EU on July 1st 2013 and Latvia adopted the common currency on January 1st 2014, increasing the EA member states to 18, more countries (mainly from ex-Yugoslavia) are applying for membership in the EU.

1.2 Macroeconomic convergence

Prospects of EU membership played a pivotal role in the transition process of the 10 CEECs, constituting both the reason and the catalyst for a rapid and successful transformation of economic structures, and convergence to Western European standards. On one side, countries were stimulated to enact fast reforms in order to participate in the EU and enjoy the benefits of membership in terms of free trade and movement of capital and people. On the other hand, prospects of participation in a community characterized by democratic structures, sound macroeconomic policies, free and open markets provided domestic and international investors with stable expectations on the future economic outlook. Such stability of expectations encouraged investment in the region, both in physical and human capital, which was of key importance in sustaining the transition process.

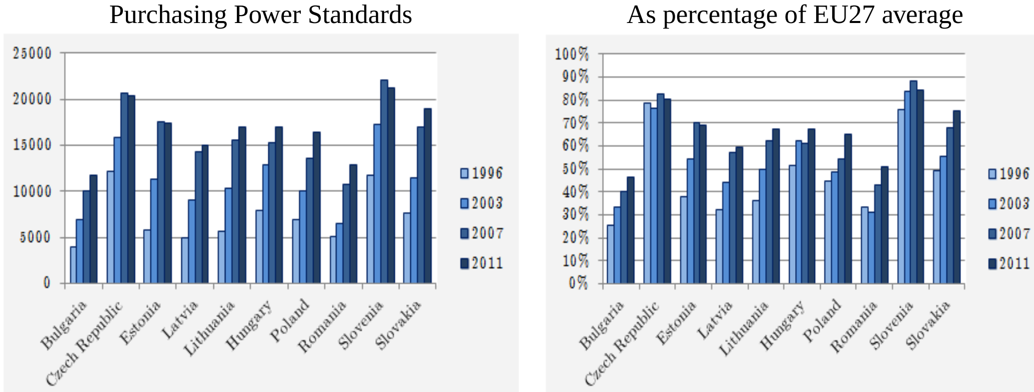
During the transition period and the years preceding EU membership, the CEECs engaged in a catching-up process to align their macroeconomic performance to that of their Western peers. The convergence process was further incited by the requirement to comply to the Maastricht criteria, as a necessary prerequisite for EMU membership.[4] The extent of the catching-up process is evident from Figure 1.2, which depicts real per capita GDP in the New Member States (NMS) both in absolute terms (Purchasing Power Standards) and as a percentage of the EU average. In 1996, the average purchasing power-adjusted per capital income in the NMS was 46% of that of the EU. However, important cross-country differences existed: while Czech and

[4] The Maastricht criteria impose a set of rules on macroeconomic stability, defined in the Maastricht Treaty, countries have to comply to in order to be eligible for membership in the EA. These criteria involve aspects related to price stability, sustainability and soundness of public finances, exchange rate stability and long-term interest rate convergence.

Slovenian per capita GDP were higher than 70% of EU real per capita GDP, Bulgaria was considerably poorer, followed by the Baltic countries and Romania. However, by 2003, real per capita GDP increased substantially, reaching, on average 54% of the EU average. By 2007, and even more in 2011, real per capita convergence further increased. However, cross-country differences still persist: while some countries (the Czech Republic and Slovenia) display real per capita GDP equal to 80% of the EU average, the Bulgarian and Romanian population are around 50% poorer than the average EU inhabitant.

Figure 1.2: Real per-capita GDP in PPP and as a percentage of EU average

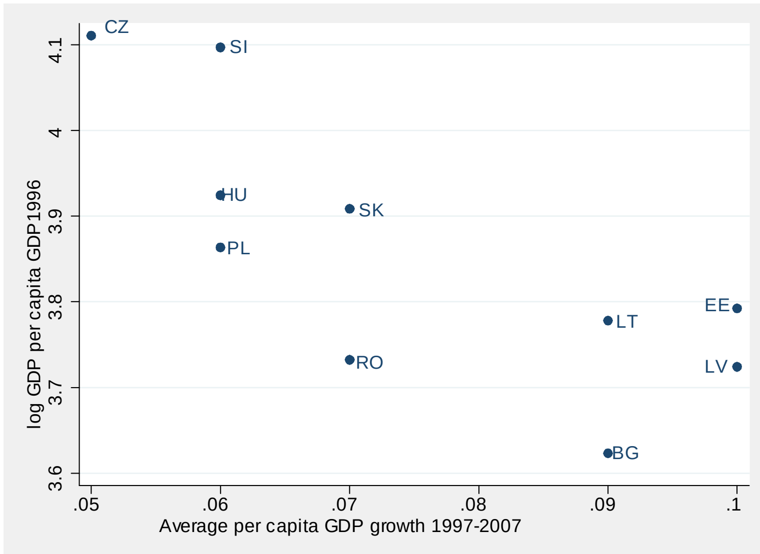
Purchasing Power Standards | As percentage of EU27 average



Source: Own calculations based on Eurostat data.

The speed of convergence varied across countries, as shown in Figure 1.3: in line with the convergence hypothesis, countries starting at a low level of income (i.e. the three Baltic countries and Bulgaria) grew faster than countries characterized by a higher initial income (i.e. the Czech Republic and Slovenia). The figure highlights a clear negative relationship between the level of real GDP per capita in 1996 ($y-$axis) and the average per capita real GDP growth in the decade 1997-2007 (x-axis).

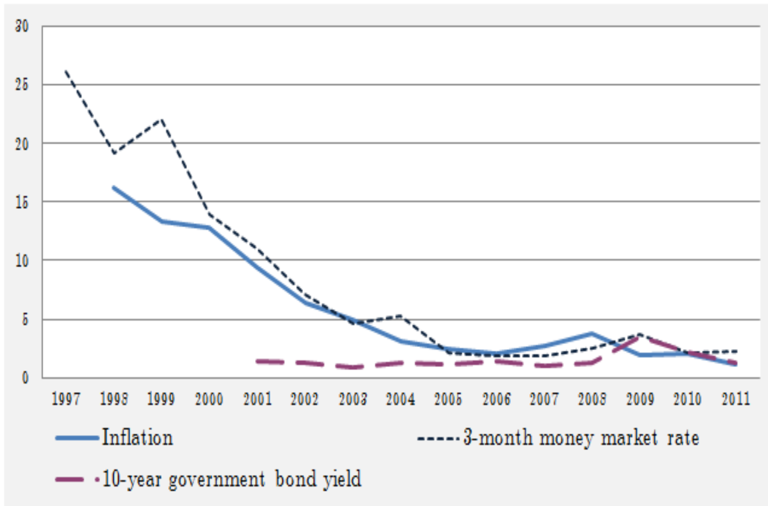
Figure 1.3: Real GDP convergence



*Source:*Eurostat and own calculations .

A bird's eye picture of the overall process of convergence can be drawn by looking at Figure 1.4, which depicts the dispersion of the main indicators of nominal convergence, namely inflation, short and long term interest rates, from the 1997 to 2011.

Figure 1.4: Standard deviation of main nominal convergence indicators across NMS



Source: Own calculations based on Eurostat data. The countries considered are: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia.

At the beginning of the transition process, all countries were characterized by high inflation, which in most cases reached double-digit figures. However, in a short time period all countries managed to curb inflation and to bring it closer to the EA average. A similar pattern of convergence can be observed in short and long term interest rates, represented by the blue and purple dashed lines in Figure 1.4 respectively.

1.3 Trade and Financial Integration

The transition process was accompanied by an increasing degree of trade openness of the CEE economies, reflected in both trade and financial flows.

Table 1.1 shows the time evolution of the degree of openness, defined as the ratio between the sum of imports and exports of goods and services as a percentage of GDP, for the NMS and the Euro Area. As it is evident, the CEE countries are characterized by a high degree of trade openness, which is much greater than the average

Table 1.1: Trade opennes in the NMS: sum of imports and exports as a percentage of GDP (period averages)

	1996-1999	2000-2003	2004-2007
Bulgaria	115.5	105.8	122.5
Czech Republic	103.6	121.6	128.9
Estonia	148.5	157.5	153.5
Latvia	97.7	93.5	107.8
Lithuania	102.9	104.5	120.3
Hungary	115.8	138.1	145.6
Poland	51.9	62.1	79.7
Romania	59.4	74.5	76.5
Slovenia	101.6	109.7	128.9
Slovakia	123.9	150.0	164.2
Euro Area	61.8	71.3	75.9

Source: own calculations based on Eurostat data.

of Euro Area countries. Furthermore, the degree of trade openness is increasing over time: being on average 102% in the period 1996-1998, it reached 122% between 2003 and 2007. However, large cross-country differences are noticeable. While Estonia and Slovakia exhibit significant degrees of openness since the mid-1990s, countries like Poland and Romania are relatively more closed.

Considering more specifically the trade relations between the NMS and the EA, Table 1.2 reveals a tightening of the trade ties between the two areas. The table presents the time evolution of bilateral trade shares, defined as the ratio of imports and exports of each country from/to the Euro Area as a percentage of total imports/exports. It is quite evident that the EA has become an increasingly important trade partner for the NMS. With the exception of Estonia (whose main trade partners are Sweden, Latvia and Russia, other than Finland), in 1999 exports (imports) to the EA accounted for, on average, 54% (51%) of total NMS' exports (imports). Overall, the total EA import/export share in NMS' imports and exports increased during the past decade. Finally, the table reveals that not only the EA is an important trading partner for the NMS, but the reverse is also true. The last two rows of table 1.2

Table 1.2: Import and export shares of the NMS vis-à-vis the Euro Area

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Trade shares with Euro Area													
CZ													
	Imports	0.56	0.55	0.55	0.54	0.53	0.54	0.51	0.57	0.57	0.53	0.54	0.52
	Exports	0.62	0.61	0.60	0.59	0.61	0.60	0.57	0.56	0.54	0.54	0.55	0.55
EE													
	Imports	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
	Exports	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
HU													
	Imports	0.58	0.52	0.51	0.50	0.49	0.56	0.52	0.51	0.49	0.49	0.48	0.48
	Exports	0.69	0.68	0.67	0.63	0.62	0.59	0.55	0.52	0.50	0.48	0.48	0.47
LV													
	Imports	0.45	0.45	0.45	0.46	0.44	0.40	0.40	0.42	0.41	0.38	0.37	0.39
	Exports	0.33	0.35	0.35	0.34	0.35	0.32	0.33	0.34	0.33	0.32	0.33	0.31
LT													
	Imports	0.35	0.32	0.34	0.35	0.35	0.38	0.34	0.35	0.38	0.30	0.30	0.30
	Exports	0.36	0.32	0.28	0.28	0.30	0.34	0.32	0.29	0.29	0.27	0.32	0.30
PL													
	Imports	0.53	0.50	0.50	0.51	0.51	0.49	0.56	0.54	0.54	0.53	0.53	0.53
	Exports	0.60	0.59	0.57	0.56	0.56	0.54	0.52	0.51	0.49	0.48	0.51	0.51
RO													
	Imports	0.53	0.50	0.51	0.52	0.51	0.49	0.45	0.46	0.49	0.47	0.49	0.47
	Exports	0.59	0.56	0.60	0.59	0.59	0.56	0.51	0.50	0.50	0.49	0.53	0.51
SI													
	Imports	0.61	0.60	0.61	0.61	0.61	0.70	0.63	0.62	0.59	0.56	0.56	0.53
	Exports	0.62	0.59	0.57	0.54	0.53	0.53	0.51	0.50	0.48	0.47	0.49	0.50
SK													
	Imports	0.47	0.43	0.44	0.43	0.48	0.46	0.43	0.41	0.40	0.37	0.36	0.36
	Exports	0.55	0.55	0.55	0.55	0.58	0.56	0.50	0.48	0.47	0.45	0.45	0.46
Total NMS													
	Imports	0.29	0.27	0.29	0.29	0.28	0.29	0.29	0.30	0.31	0.31	0.27	0.27
	Exports	0.32	0.33	0.34	0.33	0.33	0.34	0.34	0.34	0.34	0.33	0.29	0.29
Trade share EA with NMS													
EA													
	Imports	0.09	0.08	0.09	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12
	Exports	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.13	0.14	0.13	0.12	0.13

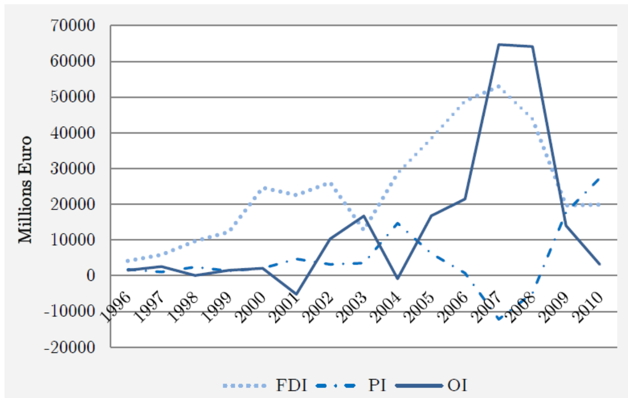
Source: own calculations based on IMF's Direction of Trade Statistics.

show the share of imports and exports from and to the EA to and from the NMS, as a share of total EA imports and exports. While in 1999 imports (exports) to the NMS amounted to 9% (10%) of total EA imports (exports), by 2010 they reached values of 12% (13%).

The transition period was also accompanied by a dramatic increase in openness of the capital account. Capital account liberalization proceeded at different paces in the transition countries: while the Czech Republic and the Baltic countries can be considered fast liberalizers, as restrictions to most transactions were removed by 1995, Hungary, Poland, the Slovak Republic and Slovenia achieved full capital account liberalization only in the first years of the new millennium.[5] The increased macroeconomic stability, an economic outlook characterized by stable economic growth and prospects of EU membership prompted foreign investors to direct large amounts of capital to the region, attracted by new investment opportunities and higher returns.

[5] The reader is referred to Arvai (2005) for a review of the process of capital account liberalization in the transition economies, and for a description of the difficulties posed by increased foreign capital flows on economic policy. Other studies that focus on the experience of the new EU member states concerning capital flows are: Lipschitz, Lane and Mourmouras (2002), Bakker and Chapple (2003), Buiter and Taci (2003) focusing on the interactions between capital flows and the financial sector, and Lane and Milesi-Ferretti (2007).

Figure 1.5: Gross capital inflows to the NMS



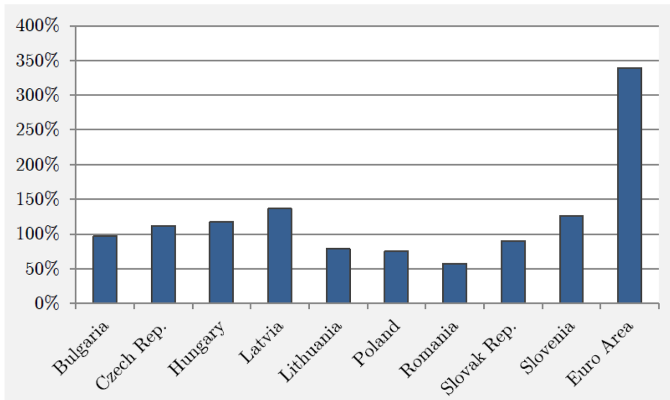
Source: Eurostat

The CEE countries have been recipients of large capital inflows since the beginning of the transition process. Figure 1.5 provides an outlook of the evolution of gross capital inflows to the NMS as a whole. Specifically, three categories of inflows are depicted: foreign direct investment (FDI), portfolio investment (PI) and other investment (OI, a residual category comprising bank loans, trade credits and transactions in currency and deposits). The figure shows a clear increasing trend of capital inflows since the mid-1990s. Moreover, while during the 1990s foreign direct investment was the predominant form of foreign investment, since the mid 2000s short-term capital inflows in the form of cross-border loans became predominant.[6]

One of the reasons for the massive injections of foreign capital since the beginning of transition was the limited development of NMS' financial sectors, that weren't able to match the demand for financing driven by increased domestic demand for investments and consumption. In fact, the banking sector in the NMS is still small relative to the size of their economy.

[6] See Pirovano, Vanneste and Van Poeck (2009) for a country breakdown of the composition of capital inflows to the NMS.

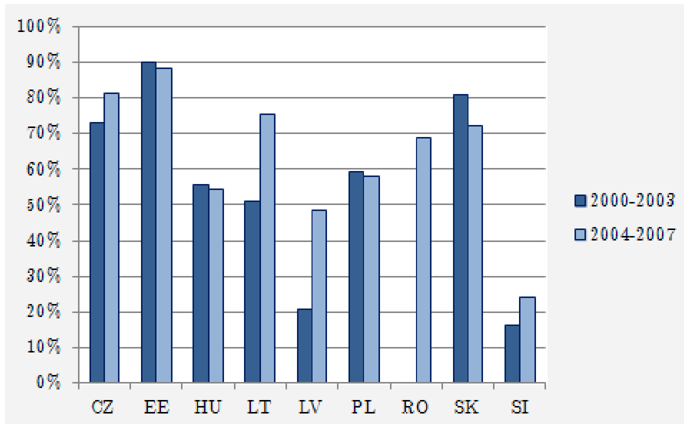
Figure 1.6: Banks' assets as a percentage of GDP, 2008



Source: own calculations based on ECB data. Data for Estonia not available.

Figure 1.6 depicts total assets of monetary and financial institutions as a percentage of GDP in the NMS and in the EA in 2008. The discrepancy between old and new member states is striking. While the average of the EA reaches 339% of GDP, the figures for the NMS range between 50% and 137% of GDP. The rapid increase in foreign lending to the NMS is a direct consequence of the extensive presence of foreign banks in the region. Equipped with consolidated management strategies, attracted by the possibility to capture market shares and helped by loose licensing in the destination countries, Euro Area banks invested massively in the region, establishing a large number of branches and subsidiaries.

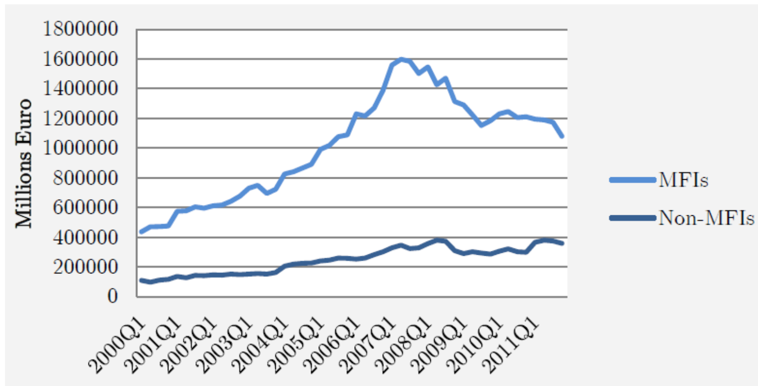
Figure 1.7: Assets of EU credit institutions as a percentage of total assets of credit institutions



Source: Own calculations based on ECB data

Figure 1.7 depicts the share of assets owned by EU credit institutions as a percentage to total assets in the NMS. As it is evident, in all countries except Slovenia, foreign credit institutions hold more than half of total assets and this percentage is particularly elevated in the Czech Republic (more than 80% in 2008), Estonia (slightly less than 90%) and the Slovak republic (circa 72%). Being better capitalized and enjoying easier access to foreign financing through their parents in Western Europe, foreign banks intermediated a large amount of cross-border loans, resulting from increased demand for credit which could not be satisfied by domestic savings only. Increased demand for foreign financing resulted in heavy reliance of the CEECs on loans originating mainly in European economies, and large exposures of European parent banks in the host countries. As we will see later, heavy reliance on foreign loans and tight lending relationships with Western Europe exposed the NMS to financial imbalances and were crucial in transmitting the crisis to this part of the European continent.

Figure 1.8: Lending from Euro Area banks to NMS' financial (MFI) and non-financial (Non-MFI) institutions



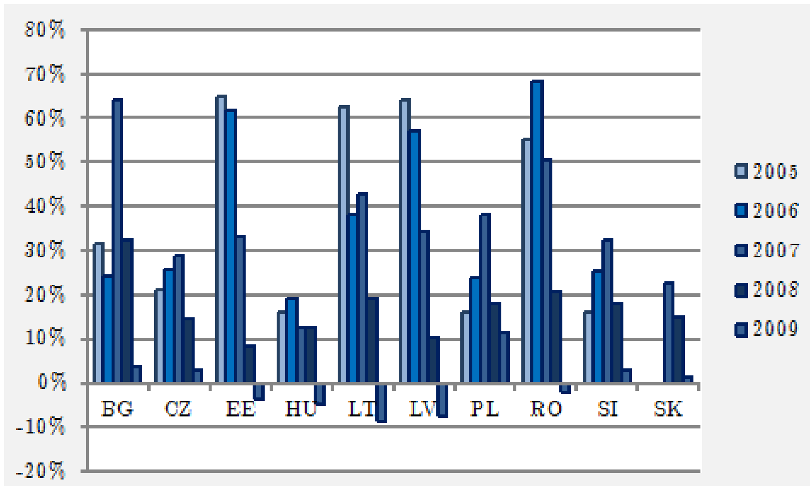
Source: ECB

Figure 1.8 depicts the evolution of bank loans originating in the Euro Area directed to NMS' financial (MFI) and non-financial (Non-MFI) institutions. The increase in foreign loans to the CEECs was particularly evident in the run-up to EU membership and was in vast majority directed to monetary and financial institutions that channeled funds to households and firms in the form of loans.

1.4 Macro-financial imbalances in the run-up to the financial crisis

As illustrated in the previous sections, the CEE countries underwent a period of remarkable economic performance, characterized by increased economic growth and development. The period of economic stability and enhanced prosperity was accompanied by a surge in domestic demand (both for consumption and investment purposes), fuelled by the availability of credit and fostered, to a large extent, by the massive wave of foreign capital flowing in the region.

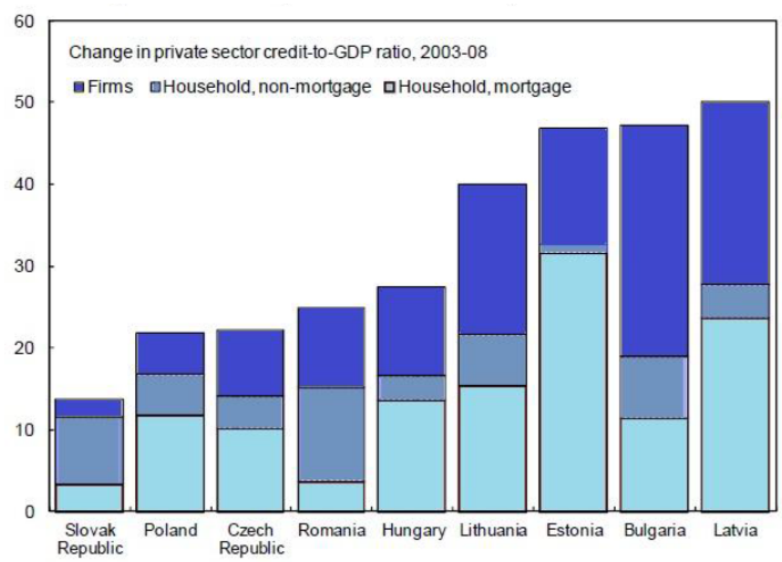
Figure 1.9: Credit growth (yearly)



Source: ECB

Figure 1.9 portrays total credit growth in the NMS in the years preceding the financial crisis. Cross-country heterogeneities are immediately noticeable: while in countries like the Czech Republic and Hungary credit growth was contained below 30%, the Baltic countries, Bulgaria and Romania exhibit striking figures. In 2005, annual credit growth in the Baltic countries exceeded 60%, while Romania attained a record credit growth of almost 70% in 2006.

Figure 1.10: Credit growth, sectoral decomposition

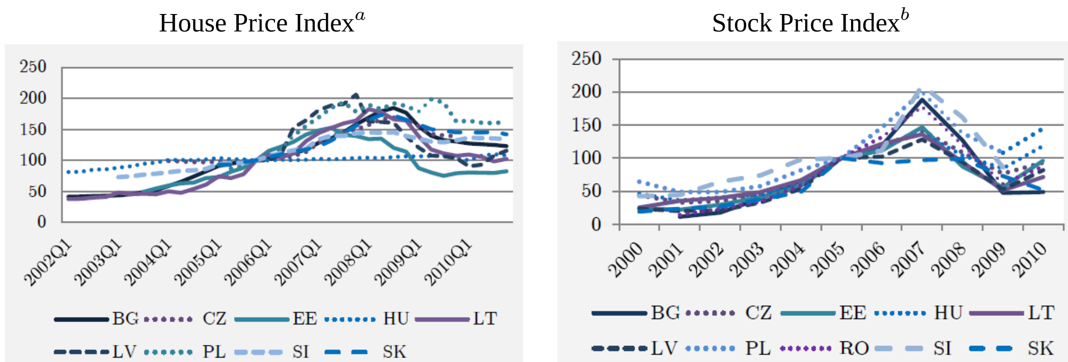


Source: Bakker and Gulde (2010)

Credit growth involved both the household and the corporate sector. Figure 1.10 depicts the decomposition of total credit growth according to the sectoral destination, distinguishing between loans to firms, loans for housing purchase and non-housing loans. In some countries, such as the Baltics and Hungary, credit for mortgage purposes constituted a conspicuous share of total credit. On the other hand, in countries like Bulgaria credit to households in the boom years was small relative to corporate credit, while credit for consumption purposes was proportionally larger in the Slovak Republic and Romania.

Although empirical evidence (Kiss et al. (2006)) reveals that credit growth in the NMS was largely justified by economic fundamentals and was a natural result of the increase in domestic demand, credit dynamics in Emerging Europe posed a challenge to macro-financial stability on three grounds. First, rapid growth in bank credit and asset prices significantly contributed to financial fragility, by increasing leverage and hampering the resilience of the economy during downturns. The availability of cheaper credit and the consequent increased demand for real estate investment inflated real estate prices, with a positive effect on consumption through wealth effects. At the same time, investment in the corporate sector increased to several times its level at the beginning of the decade, fueling asset prices growth. As a result, in the years preceding the global financial turmoil, both house and asset prices exhibit an increasing trend in the countries in the region, as Figure 1.11 shows.

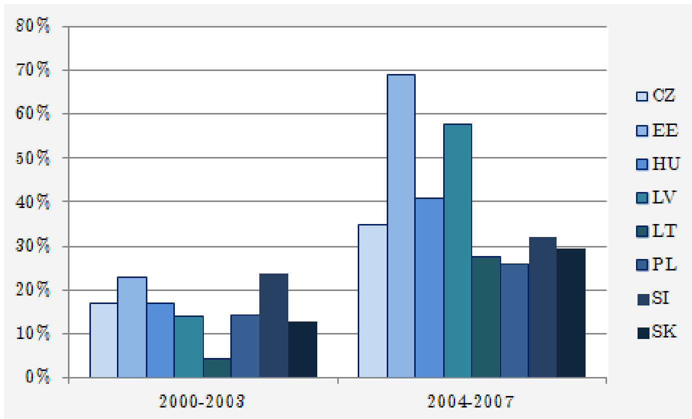
Figure 1.11: Evolution of asset prices in the NMS



Source: [a]: BIS; [b]: Eurostat

The surge in borrowing resulted in an increase in household leverage across countries in the region (Figure 1.12). While in the three-year period from 2000 to 2003, the debt to income ratio of households ranged between less than 5% (Lithuania) and 24% (Slovenia), in the time interval from 2004 to 2007 all countries registered debt to income ratios higher than 25%, with Estonia and Latvia settling on values of 68% and 57% respectively.

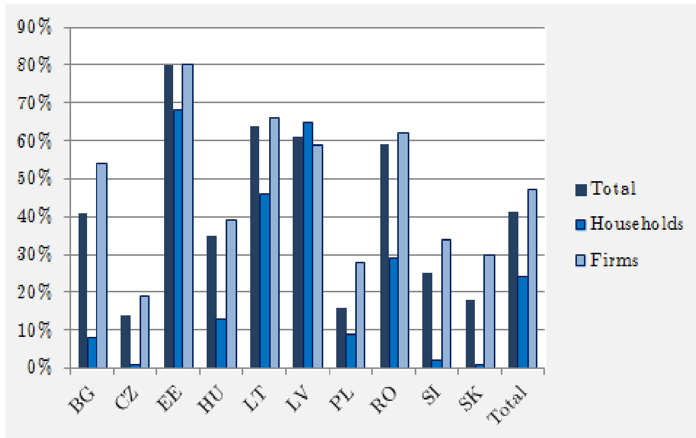
Figure 1.12: Households' gross debt-to-income ratio, period averages



Source: Eurostat

A further source of concern involves the large share of liability dollarization and resulting currency mismatches in borrowers' balance sheets. In fact, in Eastern European countries, a considerable fraction of credit to the private sector was denominated in foreign currency. As Figure 1.13 shows, a considerable share of loans to both household (i.e. mortgage loans) and firms were granted in foreign currency. This is particularly evident in the Baltic countries (registering shares higher than 60%), Bulgaria and Romania, although in the other countries of the region the phenomenon is not negligible.

Figure 1.13: Share of foreign currency loans in total loans, average 2000-2006



Source: Basso et al. (2007)

This resulted in an increased exposure of borrowers to currency mismatches, with assets valued in domestic currency (i.e. houses, ownership of firms, capital goods etc.) and liabilities in foreign currency, posing a serious threat to macroeconomic and financial stability in case of a currency devaluation. In fact, a devaluation implies an increase in the domestic currency value of liabilities, not matched by a proportional increase in the value of assets, which pushes up leverage and deteriorates borrowers' balance sheets.

Finally, the increased dependence on foreign financing exposed countries to risks of contagion from external developments, which became evident during the financial crisis.

1.5 The financial crisis

Trade and financial openness, and the macro-financial imbalances characterizing the NMS in the run-up to the financial crisis were crucial in determining the crisis' spread and intensity.While not being directly exposed to toxic assets, the small open economies of Central and Eastern Europe were dragged into the spiral through their trade and financial ties with Western Europe.

As it is evident from Figure 1.5, all three categories of capital inflows declined sharply when the crisis hit. While portfolio investment, composed of investment in equity and debt securities turned to negative as soon as the crisis hit, foreign direct investment and other investment decreased by more than 50% between 2007 and 2009. When the financial crisis spread to Western Europe, banks interrupted the flow of lending to the NMS, depriving them of their main form of financing. As Figure 1.8 reveals, lending from EA banks to NMS' monetary and financial institutions declined by 30% from 2007 to 2009, after a period of steady increase. The spread of uncertainty and scarcity of liquidity led to a repricing of credit and a tightening of credit conditions, which discouraged new borrowers and put the existing ones under strain. Furthermore, as capital outflows put downward pressure on domestic currencies, borrowers with liabilities denominated in foreign currencies saw the value of their debt increase, implying a further deterioration in borrowing conditions.

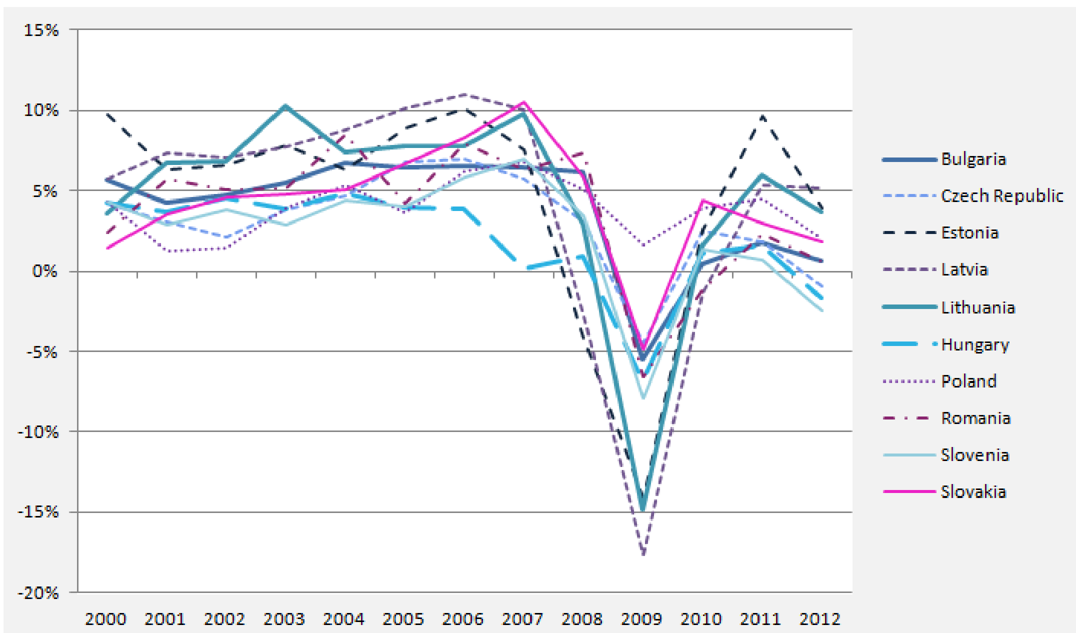
Table 1.3: Import and export volumes, percentage change from previous year

	Bulgaria		Czech Republic		Estonia		Latvia		Lithuania	
	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp
2006	45.2	95.7	10.7	14.0	15.2	7.8	20.9	3.2	13.3	13.4
2007	10.1	6.2	13.7	11.4	5.7	2.1	16.6	8.3	9.5	5.2
2008	3.5	4.1	2.1	3.0	-7.2	-0.5	-12.3	1.0	10.4	13.5
2009	-22.7	-11.4	-12.8	-11.8	-33.0	-25.5	-33.2	-10.7	-29.3	-11.9
2010	6.4	19.8	16.0	16.4	23.7	33.6	14.8	19.8	20.8	18.0
2011	11.4	16.6	7.0	10.6	29.9	30.0	25.1	11.8	13.2	13.5
2012	4.5	-0.9	1.6	4.2	8.4	7.2	4.7	11.0		
	Hungary		**Poland**		**Romania**		**Slovenia**		**Slovakia**	
	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp	Exp
2006	14.8	17.5	16.8	13.8	23.7	7.1	12.7	13.4	19.0	22.1
2007	12.0	15.7	15.1	7.0	30.9	7.3	16.2	13.9	8.6	15.1
2008	5.1	5.6	8.5	7.8	4.7	3.8	3.0	1.8	1.5	3.6
2009	-17.2	-13.1	-14.3	-8.5	-23.1	-3.6	-20.2	-16.6	-19.1	-15.2
2010	13.1	12.8	13.7	13.1	17.0	19.1	8.3	12.0	17.5	17.7
2011	6.7	9.1	6.2	7.7	10.7	12.2	6.6	8.2	11.1	12.9
2012	0.3	2.1	-1.7	3.3	-1.2	-4.3	-5.1	-0.1	3.8	9.7

Source: Eurostat.

Trade ties also contributed in reinforceing the impact of the crisis in the CEE countries. As demand in Western Europe decreased as a consequence of the crisis and prices of imported goods increased thanks to the currency depreciation, the NMS saw a reduction in commercial exchanges. Table 1.3 reports the year-on-year percentage changes in the volume of imports and exports in the CEECs. Between 2008 and 2009, both imports and exports reduced dramatically, with the most acute decrease happening in the Baltic countries.

Figure 1.14: Nominal GDP growth in the CEECs (yearly percentage change)



Source: Basso et al. (2007)

As a result of the global crisis, the NMS suffered large losses in terms of GDP growth, as Figure 1.14 shows. However, heterogeneities in economic performance are noticeable. Specifically, countries which experienced the strongest credit boom before the crisis and large macroeconomic and financial imbalances (notably, the

Baltic countries) faced the largest contraction in GDP growth (Bakker and Gulde (2010))[7].

1.6 Monetary and exchange rate policy

As illustrated at the beginning of this chapter, the countries of Central and Eastern Europe engaged in a remarkable process of convergence. By the beginning of the new millennium, countries exhibited robust growth and inflation declining below double-digit figures. This common tendency was, however, associated with different exchange rate arrangements and monetary policy strategies. Table 1.4 provides an overview of the time evolution of monetary policy and exchange rate strategies in the NMS.

In the first years of transition, all countries in the region were characterized with high macroeconomic volatility and inflation instability and set economic stability as the top priority. For some countries, setting a nominal anchor to the currency seemed the more viable strategy to achieve this objective, and opted for pegged exchange rate regimes. Other countries, like Bulgaria and Romania and Slovenia settled for flexible currencies, probably in light of the scarcity of international reserves to back the currency. As inflationary pressures weakened in subsequent years, an increasing number of countries opted for more flexibility and adopted inflation targeting as their monetary policy strategy at the end of the '90s. From 1994 to 2000,

[7] In a recent study, Mitra (2011) argues that sectoral destination of capital flows is an important determinant of the impact of the crisis. She observes that countries that suffered the largest swings in GDP growth coincide with those where capital inflows were heavily channeled to real estate and to the household sector. The heaviest impact of the crisis on these countries might be related to two aspects. On one side, to the credit crunch that severely limited the credit supply that fostered consumption and hence GDP growth. In comparison, countries where credit was channeled to the production sector could rely on higher productivity brought about by newly installed capital, better competitivity and thus a better export performance, which limited the extent of the downturn. On the other hand, the three Baltic Republics committed to a fixed exchange rate regime, thereby constraining the room for manoevre of monetary policy authorities and renouncing to the benefits of a currency depreciation that would have followed the sudden stop in capital flows.

Table 1.4: Official monetary policy strategies and exchange arrangements in the NMS

	Monetary policy strategy	Exchange rate arrangement
[0.5ex] Bulgaria	Until 1997: Money growth targeting Since 1997: Nominal ER anchor	Until 1997: Managed float Since 1997: Currency board
Czech Rep.	1994-97: ER and monetary targeting 1998-2001: Net inflation targeting Since 2002: headline inflation targeting	1994-96: Basket peg ($\pm$ 0.5% band) 1996-97: Widening band to $\pm$ 7.5% Since 1997: Managed float
Estonia	Until 2011: Nominal ER anchor Since 2011: Euro Area member	1992-2004: Currency board 2004-2011: ERM II Since 2011: Euro
Hungary	1994-2002: ER targeting Since 2002: inflation targeting	1994-99: Crawling peg (basket), $\pm$ 2.25% band 2000-2001: Crawling peg100% Euro 2001: widening band to $\pm$ 15% 2001-08: Peg to Euro, $\pm$ 15% band Since 2008: Managed float
Latvia	Since 1994: ER targeting	Since 1994: fixed peg 2005: ERM II Since 2014: Euro
Lithuania	Nominal ER anchor	1992-94: Managed float 1994-2004: Currency board Since 2004: ERM II
Poland	1994-98: ER targeting Since 98: inflation targeting	1994-95: Crawling peg, $\pm$ 1% band 1995-98: Widening band to $\pm$ 7% 1998-2000: Widening band to $\pm$ 10% Since 2000: Free float
Romania	1994-2005: No specific commitment to strategy since 2005: inflation targeting	Since 1994: Managed float
Slovakia	1994-98: ER targeting 1998-2008: informal inflation targeting since 2009: Euro Area member	1994-96: Basket peg $\pm$ 1.5% band 1997-98: Widening band to $\pm$ 7% 1998:2005: Managed float 2005-08: ERM II Since 2009: Euro
Slovenia	1994-2000: Monetary targeting 2001-06: Two pilliar strategy Since 2007: Euro Area member	1994-2004: Managed float 2004-06: ERM II Since 2007: Euro
[0.5ex]		

Source: Barisitz (2004, 2007), Frömmel et al. (2011)

most countries opted for managed or full exchange rate flexibility, while Estonia and Lithuania maintained their currency board arrangement and Latvia followed a strict peg. Against this tendency, Bulgaria switched from full flexibility to a currency board arrangement in 1996. The years after 2000 and the more concrete prospects of EU members led many countries to reconsider their exchange rate strategies in order to align them with the prescriptions of the Maastricht Treaty. In particular, a prerequisite for euro adoption is participation in the Exchange Rate Mechanism II (ERM II), which entails pegging the currency to the euro with limited fluctuations around the agreed parity (not exceeding $\pm 15\%$). Therefore, Lithuania and Latvia, switched their reference currency from the U.S. dollar and the SDR respectively, to the euro in 2002. ERM II was officially adopted in 2004 by Estonia, Lithuania and Slovenia, whereas Latvia and Slovakia followed a year later. Formal euro adoption has been so far achieved by four countries (Slovakia, Slovenia, Estonia and Latvia), while the other countries are committed to do so as soon as they comply with the necessary criteria in terms of inflation stability, government finance and exchange rate stability. Currently, the Czech Republic, Hungary and Poland are operating under a floating exchane rate regime (Hungary introduced it in 2008).

In general, the choice of the exchange rate strategy crucially hinges on balancing the trade-off between flexibility and stability. On one side, allowing the currency to fluctuate freely grants the monetary authority more room for manoevre, which can be helpful in supporting domestic policy objectives. On the other hand, adopting a less flexible regime, while constraining domestic policy instruments, acts as a powerful anchor for expectations (especially of foreign investors), contributing to lower and more stable inflation. In fact, while in large and relatively closed economies exchange rate fluctuations have a negligible impact on inflation, given the small weights of imports in the price level, changes in the (domestic currency) price of imports can considerably destabilize inflation in small open economies where imports constitute a large fraction of the consumption basket. Furthermore, in countries characterized by a large degree of liability dollarization, anchoring the nominal value of the currency might look desirable in order to avoid unfavorable increases in the value of debt following shocks with devaluation pressures.

While the choice of exchange rate arrangement and monetary policy strategy did not seem to be discriminant in determining differences in the catching up and convergence process of the NMS in the transition period and in the run-up to EU membership, it had an impact on the accumulation of macro-financial imbalances and on the impact of the global financial crisis. As it can be seen comparing figures 1.9, 1.13 and 1.14, countries operating under a strict peg or a currency board arrangement (i.e. the Baltic countries and Bulgaria), experienced both the fastest credit growth and the largest degree of liability dollarization prior to the crisis, and suffered the greatest losses in terms of GDP growth when the financial crisis hit. As we will see in the following chapters, the exchange rate regime and the monetary policy strategy of a central bank in economies characterized by a high degree of trade and financial openness are crucial in determining the build-up of vulnerabilities and the reaction to foreign shocks. Finally, the extent of trade and financial integration with the EA makes the small open economies of Central and Eastern Europe not immune to the stance of EA monetary policy. On one side, shocks to the foreign monetary policy can have important consequences for the exchange rate and asset prices in small open economies; on the other side, the reaction of the EA central bank to EA shocks is very important for the transmission of such shocks to small open economies, and the intensity of transmission is strictly linked to the exchange rate arrangement adopted by the latter.

1.7 Overview of the dissertation

The present dissertation analyzes issues related to monetary and exchange rate policy in small open economies presenting the characteristics of the Central and Eastern European economies illustrated in the previous sections. In the following chapters, one empirical and two theoretical essays are presented, all of which featuring a small open economy affected by both domestic and foreign shocks. The concepts of financial openness and integration together with their interplay with monetary and exchange rate policy are the leitmotif of this dissertation, recurring in every chapter albeit under different points of view. While the focus of the essays is not on the global financial crisis, the recent turmoil is of crucial importance in that it led to the reconsideration of many aspects of macroeconomic modeling and monetary policy making which are at the core of the subsequent chapters.

First, the crisis led to a renewed interest in the interplay between monetary policy and asset prices. A large body of studies tackled this issue even in years preceding the crisis, nevertheless their focus was on advanced economies. While these studies concluded for a significantly negative effect of a (domestic) monetary policy contraction on the stock price index, it is natural to ask whether this finding holds also for small economies characterized by tight trade and financial linkages with larger countries. Section 1.3 highlighted the extent of trade integration between the NMS and the EA, establishing the key role of Western Europe as a destination market for CEE goods and a provider of imports, of which intermediate goods constitute a significant share.[8] Furthermore, the NMS have been heavily dependent on loans originating from the Euro Area. As a result of these developments, it is reasonable

[8] A study performed by the CEPII (2009) reports that several new member states (Czech Republic, Hungary, Poland, Slovakia and Slovenia), have high shares of intermediates in total imports, particularly originating from the "old" members of the EU. Furthermore, all NMS exhibit significant increases in their intermediate goods imports, reaching levels higher than the EU average of 70%. While in some countries (e.g. the Baltic States) such imports origin mainly from other NMS, others significantly imported from the rest of the world (Hungary, Poland), and the "old" member states (Czech Republic and Slovakia).

to assume that cash flows of NMS's firms, and hence stock prices, might be increasingly influenced by Euro Area monetary policy. In particular, the increased trade and financial openness of Central and Eastern European Countries can affect their firms' performance through movements in borrowing and exchange rates, and demand effects. For instance, an increase in EA interest rate resulting in an appreciation of the euro increases the cost of imported intermediate goods and decreases output of firms in CEECs, exerting a negative effect on stock prices. Furthermore, for firms relying on foreign funding, an increase in foreign interest rates translates in an increase in borrowing costs, making it more difficult to service existing loans and more expensive to contract new ones. In addition, demand effects of contractionary monetary policy in the EA reduce demand for NMS' exports if quantity effects dominate the consumption switching effect of CEECs' exchange rate depreciation. Finally, as EA interest rates increase, foreign investors might sell stocks held in NMS to invest in interest bearing securities in EA. For all the aformentioned reasons, the first essay of this dissertation (Chapter 3) examines empirically the response of stock prices in four NMS to shocks to both domestic and foreign (Euro Area) monetary policy. The results reveal that, while domestic monetary policy shocks do not exert a significant impact on stock prices, unexpected changes in Euro Area monetary policy do. Specifically, a contraction in foreign monetary policy reduces stock prices in the NMS. Furthermore, variables associated with international finance and trade (namely the exchange rate and the foreign interest rate, are the main determinants of the variability of stock prices in the considered countries. This seems to suggest that in small economies characterized by a high degree of openness, stock markets are more sensitive to shocks related to international trade and finance.

A second issue the financial crisis led to reconsider, strictly linked to the first, is the role of the financial sector as a source and propagation channel for shocks. While imbalances in the United States' financial sector were at the roots of the turmoil, distress was quickly transmitted to international financial markets and real economies worldwide. Heavy losses on the asset side of the balance sheet led banks to reduce lending both domestically and internationally. As shown in section 1.5, the international credit crunch resulted in a sudden stop of capital flows to emerging economies and to the NMS, which were particularly dependent on foreign bank loans before the crisis. As illustrated earlier, however, countries which experienced the largest amount of capital inflows, the strongest credit and real estate booms, and largest macroeconomic and financial imbalances before the crisis faced the largest contraction in GDP growth. Furthermore, these countries share the common feature of having adopted a fixed exchange rate during most of the pre-crisis period. Chapters 4 and 5 of this dissertation present two modeling frameworks to study monetary policy conduct in small open economies explicitly accounting for the role of the financial sector as a source and propagation channel for shocks. However, the two chapters tackle the issue from two very different standpoints while adopting the same modeling framework of Dynamic Stochastic Genreal Equilibrium (DSGE).

Chapter 4 takes the perspective of the pre-crisis period, when countries were exposed to large capital inflows directed to the financing of loans to both households and firms, and were characterized by high degrees of liability dollarization. As the stylized facts presented earlier show, the build-up of imbalances and vulnerabilities in good times can significantly amplify the effect of downturns. Furthermore, it emerged that such imbalances were more pronounced in countries adopting a fixed exchange regime. In this essay, I look at the optimal monetary policy of a small open economy featuring the aforementioned characteristics and exposed to domestic technology and foreign capital inflow shocks. More specifically, the chapter is set in a small open economy DSGE framework, in which capital inflows are directed to the financing of both mortgage and investment loans. Credit frictions are present at both the entrepreneurial and household level, allowing to explore the interaction between leverage dynamics in the two sectors. In addition, liabilities in the two sectors are denominated in foreign currency, further increasing the dynamic interaction of leverage upon occurrence of the considered shocks. The objective of this essay is threefold. First, I compare the dynamics of the economy in response to productivity and capital inflow shocks under different monetary policy rules that have been widely considered in the literature for emerging economies (i.e. standard Taylor rule, Taylor rule with exchange rate smoothing and fixed exchange rate) and a Taylor rule reacting to credit growth. Secondly, the dynamic interaction between leverage at the household and entrepreneurial level is analysed and compared. Third, I compute the optimal unrestricted monetary policy rule for a small open economy subject to productivity and capital inflow shocks, under two central bank objectives, namely macroeconomic stability and macroeconomic *cum* financial stability. The analysis largely confirms the stilyzed facts. Small open economies pegging the exchange rate are characterized by a more marked macro-financial overheating following capital inflow shocks, reflected in a greater credit growth and expansion of aggregate demand, and a stronger increase in inflation. Furthermore, I find that in the case the monetary authority is not concerned with financial stability, steering the interest rate responding only to inflation and output deviations (i.e. following a standard Taylor rule) is optimal. Adding financial stability to the central bank's objectives does not result in an optimal reaction to credit growth, while some degree of reaction to exchange rate depreciation is optimal. In fact, reacting to credit growth implies a too sharp tightening of monetary policy in response to capital inflow shocks, which results in further exchange rate appreciation and further strengthens borrowers' balance sheet encouraging more foreign borrowing. This seems to suggest that in a small open and dollarized economy, a the central bank with financial stability objectives but equipped with one instrument, namely the nominal interest rate, cannot simultaneously achieve macroeconomic and financial stability.

In Chapter 5, the interplay between exchange rate regimes and the strength of cross-border financial linkages in the event of adverse foreign shocks is studied. Here, instead of modeling a single small open economy, I consider a two country DSGE model featuring two countries of different sizes which engage in trade and cross-border lending relationships. In each country banks operate internationally and are subject to balance sheet constraints. Specifically, banks in each country can borrow from both domestic and foreing lenders (depositors) and grant loans to domestic and foreign entrepreneurs for the financing of investment in capital. This framework allows to examine the transmission mechanism of real and financial shocks originating in a large and relatively closed economy to a small open economy, in addition to the effect of the foreign country's monetary policy responses on the small economy. This analysis has multiple purposes. First, it examines the transmission mechanism of foreign real and financial shocks to a small open economy under different exchange rate regimes and degrees of cross-border lending relationships. Second, it addresses the issue of the ranking of fixed and flexible exchange rate regimes and its relation with the strength of cross-border lending relationships. In particular, the relative preformance of exchange rate regimes is evaluated from the point of view of both the small open economy's central bank and the welfare of its residents. Once again, to represent the preferences of the central bank, I consider both the objectives of macroeconomic and macro *cum* financial stability. The results of the model simulation are consistent with the stylized facts. Specifically, the superiority of a flexible exchange rate regime in stabilizing the economy facing adverse foreign shocks is confirmed. Furthermore, a flexible exchange rate regime ranks higher from the perspective of both the small open economy's central bank and households' welfare. From the point of view of the small open economy's monetary authority, the relative cost of pegging the currency increases the larger its concerns for financial stability, since it involves a stronger monetary policy reaction to preserve the parity, which has repercussions on the volatility of financial variables. On the other hand, tighter cross-border lending relationships decrease the relative cost of pursuing a fixed exchange rate strategy.

Before turning to the details of the models and the presentation of results, the following chapter offers an overview of the recent studies constituting the background and the scientific context of this dissertation, highlighting the contribution each essays brings to the existing literature.

CHAPTER 2
RELEVANT LITERATURE

The economic literature following the global financial crisis is immense. Other than constituting a worldwide economic and financial earthquake affecting the lives of millions of people around the globe, the crisis severely shook the basis of the existing macroeconomic research and policy framework. Recent events led to a profound reconsideration of well-established practices and methodologies used in academic and institutional environments. All aspects of the crisis, from its causes to its consequences and the possible policy responses, spurred a lively macroeconomic debate putting into question the status quo of monetary policy research and practice. This dissertation relates to four major themes which gained momentum during and in the aftermath of the financial crisis. First, the renewed interest in the role of asset prices, and the scope of monetary policy in influencing them. Second, the attention to a particular category of asset prices, namely real estate prices, and to the role of the real estate sector in transmitting macroeconomic fluctuations. Third, the recognition of the role of leverage and of international lending relationships as a source and propagation channel for shocks. Finally, the reconsideration of the objectives and implementation of monetary policy.

This chapter presents the major findings of these strands of literature, providing the scientific underpinning to the subsequent chapters. Section 2.1 presents the empirical evidence on the interplay between monetary policy and stock prices, constituting the background for Chapter 3. Section 2.2 present a general overview of the main challenges to the prevailing practices in modeling for macroeconomic and monetary policy analysis in the aftermath of the financial crisis, paving the way for the methodology adopted in chapters 4 and 5. Sections 2.3 and 2.4 constitue the scientific underpinning of Chapter 4, illustrating advances in modeling the housing market, credit frictions and capital inflows in macroeconomic models. Section 2.5 is related to the modeling of international financial linkages and studies focussing on exchange rate regimes, which is particularly relevant to chapter 5. Finally, section 2.6 concludes presenting the debate on the reconsideration of the roles, objectives and instruments of monetary policy in the aftermath of the crisis.

2.1 Financial integration, monetary policy and stock prices

The interplay of monetary policy with stock prices was the subject of a large number of studies in the last two decades. If we think about the stock price as defined by the discounted sum of future cash flows, it is immediately clear from this very simple theoretical framework that an inverse relationship exsists between the interest rate and stock prices. As interest rates increases, the future is discounted more heavily and the current stock value decreases. In other words, as market interest rates hike, the return required for investors to hold stocks (compared, for example, to bonds or other savings instruments) increases, and the price of equity decreases. However, there is a second, indirect effect of monetary policy on stock prices, operating through its effects on cash flows. A contractionary monetary policy increases the cost of credit, limiting firms' investment opportunities, and discourages demand for firms' products from domestic consumers, reinforceing the discount factor effect in depressing stock prices. Empirical studies conducted so far broadly support the notion that monetary policy is able to significantly affect stock prices, and that the relationship between interest rates and stock prices is negative. A number of empirical studies have been produced, relying on different statistical methods. The great majority of studies relies on the methodology of structural VAR (SVAR), and focused, at least in the beginning, on the United States' stock market and the monetary policy of the FED. Thorbecke (1997) estimates a VAR model identified by means of a Choleski scheme, including monthly equity returns, output growth, inflation, and the federal funds rate. His results highlight that expansionary monetary policy has a large and positive effect on monthly stock returns. Thorbeke's results are confirmed by Rapach (2001) who identifies the shocks in his VAR model by means of long-run restrictions. Again, a negative relationship between changes in the Federal Funds rate and stock prices emerges. The same conclusions for the US are reached by Rigobon and Sack (2004), who identify their VAR by means of changes in the covariance between stock prices and interest rates after a (known) change in the variance of monetary policy shocks. International evidence on the effect of monetary policy on stock prices focuses mainly on developed countries. The earliest contribution is by Lastrapes (1998), who imposes long-run restrictions to identify a VAR model for the G7 countries and the Netherlands, which includes as endogenous variables an index of real equity prices, the interest rate, output, the price level and the nominal money stock. He finds that in many countries real equity price indices respond positively, persistently and significantly to an expansionary monetary policy shock: in particular, the effect is stronger in the Netherlands, Italy and Japan (with peaks between 2 and 3 percent). A later paper by Neri (2004) updates the results of Lastrapes considering a longer sample period for the same countries. While relying on the same methodology of structural VAR, he adopts an identification scheme based on short-run restrictions. Moreover, he models the G7 countries as small open economies, where the exchange rate plays an important role in the monetary transmission mechanism and its inclusion allows a better identification of money supply shocks. The monetary policy rule is specified such that the supply of money is a function of the monetary aggregate, the nominal exchange rate, industrial production, the consumer price index and the world commodity price index. It is therefore assumed that the Central Bank reacts to contemporaneous domestic and external economic developments. His results are in line with the notion that a contractionary monetary shock produces a decrease in stock market index, in all countries considered.

To my knowledge, the only existing study exploring the relationship between foreign monetary policy and domestic stock prices is that by Li, Iscan and Xu (2010), who study the differences in the response of the stock market to changes in monetary policy in Canada (a small open economy) and the United States (a relatively closed economy), modeling them differently according to their structural characteristics. Their analysis relies on a VAR model following Lastrapes (1998), imposing short-run identification restrictions. They find that while in the United States the response of stock prices to a contractionary monetary policy shock is large and persistent, in a small open economy such as Canada the response is smaller and less persistent. Moreover, unexpected changes in the U.S. Federal Funds rate have a significant impact on Canadian stock prices. They explain their findings in light of the high degree of openness to international finance and trade of the Canadian economy.

2.2 Macroeconomic modeling after the crisis

The recent financial crisis seriously challenged the prevailing practices in modeling for macroeconomic and monetary policy analysis, as much as to lead many economists and observers to consider it the crisis of modern macoreconomics. Most of the criticisms raised to the mainstream macoreconomic models, i.e. the Dynamic Stochastic General Equilibrium (DSGE) models, rest on the inability of such framework to foresee the financial crisis and, more in general, on the assumptions underlying the prevailing modeling setup, which are deemed inadequate to represent the complexity of economic behavior.

Criticisms to DSGE models can be grouped in two main categories. First, those challenging the very essence of this research paradigm, i.e. the type of microfoundations that form the basis of even the most stylized DSGE model. The use of the "representative individual", the rationality of expectations, the existence of market clearing conditions, the assumptions related to the completeness and efficiency of markets are considered to be major flaws in the microfoundations, unfit to represent the economic reality and the behavior of economic agents.[9] The second category of criticisms, while accepting the DSGE modeling framework, focusses on its shortcomings in explaining relevant transmission mechanisms, deriving from quantities (i. leverage) and/or sectors of the economy (i.e. the financial sector) not considered in the models prevailing before the financial crisis. This view, advocated for example by Tovar (2008), Blanchard (2009) and Wickens (2009) affirms the usefulness of current macroeconomic models in providing intuitions necessary to understand the behavior of the macroeconomy, however advocating the adoption of more realistic assumptions involving, for instance, financial markets, and the presence of a wider spectrum of economic agents.

The core structure of the mainstream new Keynesian DSGE model nests a fully micro-founded approach based on utility maximisation of agents typical of the Real Business Cycle framework with Keynesian elements such as price stickiness, inefficiency of aggregate fluctuations, and non-neutrality of money in the short run. The typical DSGE environment is populated by households, firms and a government authority in charge of conducting monetary and fiscal policy. Households face two main choices, involving the allocation of expenditure between consumption and savings, and that of their time between work and leisure. In the case of an open economy, households also choose the composition of their consumption basket between domestically and foreign produced goods. Households are monopolistic suppliers of differentiated types of labor, which allows them some bargaining power when negotiating the wage. Firms employ labor and rent capital in order to produce differen-

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[9] I refer to Meeusen (2010) and for a detailed discussion of these issues. Kirman (1992) focusses on the meaningfulness of the representative agent assumption, while De Grauwe (2009) opposes the rational expectations hypothesis proposing an alternative modeling of expectations based on heuristics and bounded rationality. A similar advocation for the recognition of the inappropriateness of the rational expectations hypothesis is presented by Akerlof and Schiller (2009). Other noteworthy criticisms of the DSGE paradigm can be found in Solow (2008), Mankiw (2006), Caballero (2010).

tiated domestic goods, which are then sold in the domestic economy and exported to the rest of the world. As firms operate in a monopolistically competitive setting, they set the price of their goods optimally. However, as it is the case for workers in their wage bargaining process, a degree of stickiness in the setting of prices and wages is introduced. In particular, it is assumed that in every period, only a fraction of firms and labor unions are allowed to reset their prices and wages, leading to a sluggish adjustment to shocks hitting the economy that increases their persistence. Capital is accumulated through investment performed by households or capital producers employing domestic and foreign goods, and it is subject to frictions such as capital adjustment costs. Fiscal policy is modeled in a stylized Ricardian setting, where the government collects taxes from households and uses them to finance government expenditure[10]. The central bank conducts moentary policy through a Taylor rule, setting the nominal short-term interest rate in response to deviations of inflation from a target and a measure of economic activity.

By far, the most important shortcoming of the "typical" DSGE model underlined by the financial crisis is the assumption of perfect and complete financial markets. In particular, in the standard model described above, relationships between real and financial variables are modeled in a very stylized manner. In the standard small open economy model, the domestic short-term interest rate and the exchange rate are the only two financial variables linking domestic and foreign policies with real activity. These models assume that financial markets are complete and efficient, characterized by risk-free financial contracts and symmetry of information. They abstract from the role of financial intermediaries, such as banks, in channeling resources from savers to borrowers. However, issues as the interaction between asset prices and balance sheets, the relevance of housing prices and the role of real estate as collateral, the

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[10] As the focus of chapters 4 and 5, is not on fiscal policy, there is no explicit role for taxes and government expenditure. A simple balanced budget equilibrium is assumed.

pro-cyclicality of the financial system and the composition of balance sheets played a crucial role in the financial turmoil, and, in order to be modeled, require abandoning such strong assumptions on financial markets. Introducing financial frictions in the standard New Keynesian DSGE model requires abandoning two assumptions. First, it is necessary to introduce heterogeneity among economic agents, thereby abandoning the representative agent framework. In a world populated by identical agents, there is no scope for borrowing and lending; on the contrary, agents heterogeneities with respect to their consumption preferences, financing constraints and productivity allows for some of them to be willing to lend wile others to be eager to borrow. Secondly, information asymmetries between agents need to be introduced, in order to generate a difference between the borrowing rate and the risk-free rate.

The approaches to introduce financial frictions in the DSGE framework are essentially of three types: the collateral constraint framework, the costly state verification approach and the introduction of explicit financial intermediaries. Both collateral constraint and costly state verification approaches introduce procyclical interactions between asset prices, the balance sheet position of borrowers and real economic activity through changes in the borrowing possibilities. However, the channel through which imperfections in financial markets impact on credit supply differ. While in the collateral constraint framework, quantity limits on credit are imposed on borrowers depending on the value of their collateral, in the costly state verification framework it is the price of credit that varies according to borrowers'balance sheet conditions.[11]

The collateral constraint framework was pioneered by Kiyotaki and Moore (1997), combining limited contract enforceability with heterogeneity of agents in their intertemporal discount factor. Kiyotaki and Moore (henceforth, KM) divide the population of agents into savers (patient) and borrowers (impatient), depending on

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[11] Brzoza-Brezina et al. (2011b) compare the properties of the two approaches in a consistent way, and find that the business cycle properties of the external finance premium framework are more in line with empirical evidence.

their consumption propensity: impatient (patient) agents have a lower (higher) intertemporal discount factor, and hence they prefer current (future) to future (current) consumption, thereby preferring to borrow (lend). Furthermore, borrowers are credit constrained, as they can only borrow against collateral. When asset prices rise, the value of collateral increases and borrowers have access to more credit. As asset prices increase in periods of economic expansion, the evolution of debt mirrors that of the business cycle, amplifying macroeconomic fluctuations.

The costly state verification approach, extensively used in the following chapters, traces its origin to the analysis by Townsend (1979) and was later incorporated in a New Keynesian DSGE framework by Bernanke, Getler and Gilchrist (1999). Townsend (1979) introduces heterogeneity among borrowers, as well as imperfect information between borrowers and lenders. In his framework, borrowers are characterized by idiosyncratic productivity, which determines the profitability of investment projects and hence the distribution of investment returns. While all agents know the ex-ante probability distribution of firm returns, only firms privately and costlessly observes the actual realized project outcome. Hence, information asymmetry applies ex-post. In this setting, borrowers have an incentive to misreport the outcome of their investment project in order not to repay the debt they contracted with lenders. Lenders can observe the project's outcome only upon payment of a monitoring cost, and they will do so whenever the borrower declares default, which creates an incentive for borrowers to report the true outcome. The debt contract between borrowers and lenders is then optimal in the sense that the verification cost is minimized. In fact, when the firm makes the contracted debt repayment, no cost is incurred. Only when the firm declares bankruptcy, and hence cannot repay its debt, verification occurs. In this instance, the firm is liquidated and its remaining assets are seized by the lender. In such a setting, optimal incentive compatible constracts are chatacterized by a positive premium induced by uncertainty on project returns and the presence of monitoring costs. hence, the asymmetric information problem leads to a higher price of credit relative to the case where credit markets are perfect. As lenders are imperfectly informed on the outcome of borrowers' investment projects, they charge a countercyclical lending premium, which positively depends on borrowers' leverage. In periods of economic upturns, asset prices increase and with them the value of firms' assets and firms' equity, thereby lowering the borrowing premium, encouraging further investment and economic expansion.[12]

The third approach introduces financial intermediaries in DSGE models explicitly, which allows to incorporate intermediation costs and issues related to banks' balance sheets. The aim of this strand of literature is to focus on the supply side of credit, providing an endogenous determination of deposit and lending spreads, accounting for the imperfect pass-through of monetary policy changes to retail banking rates, and introducing an explicit role for bank capital to influence the transmission of shocks.

A final criticism of DSGE models is of a more technical nature and relates to the most common solution method, namely linearization around the steady state. Linearization of the model equations around the seady state involves the computation of a first order approximation, which implies certainty equivalence. This means that expectations of future shocks are zero, therefore they do not influence decision rules. Furthermore, the expected value of endogenous variables is equal to their steady state value, ruling out the role of uncertainty. In genreal, linearization eliminates asymmetries, threshold effects, precautionary behavior and the consideration of large shocks. Higher order approximations of the model equations are necessarey to analyze issues

[12] Since these seminal contributions, a vast literature has flourished analyzing the role of financial frictions in originating and propagating macroeconomic fluctuations. Estimated DSGE models provide quantitative evidence in favor of the financial accelerator, and find that its presence improves the ability of models to capture the dynamics observed in the data (Elekdag et al.(2005), Christensen and Dib (2008) and Saxegaard et al. (2010)). Furthermore, Christiano et al. (2010) affirm the importance of financial shocks in accounting for a subtantial portion of economic fluctuations.

among which welfare, asset pricing and portfolio choice models, volatility shocks. The models presented in chapters 4 and 5 do not deal with this shortcoming, and still rely on a first order approximation of the models equations[13]. This choice is mainly dictated from the fact that issues such as portfolio allocations, volatility shocks and precautionary behavior are not considered in these chapters. For the purpose of the presented analysis, simulating the models relying on linearization of the model equations is adequate to answer the research questions at hand.

2.3 Incorporating the housing sector in DSGE models

In the same years, the recognition of the importance of housing as a source of collateral, and of the negative implications of housing price bubbles for economic and financial stability has spurred the attention of many macroeconomic researchers.[14] Therefore, a growing number of studies have begun to appear, modeling collateral constraints in housing investment, following the financial accelerator framework of Kiyotaki and Moore (1997).[15] The study that paved the way for research in the field is by Iacoviello (2005), who reproduces the positive correlation between spending and house price shocks introducing collateral constraints in real estate and capital investment.[16] Furthermore, he finds that, allowing the central bank to respond to asset prices does not improve its performance in stabilizing output and inflation. Christensen et al. (2007) extend the Iacoviello framework to an open economy setting

[13] However, in chapter 5, the analysis of households' welfare is based on a second order apporximation of the model.

[14] I refer to Iacoviello (2010) for a review of the stilyzed facts on the housing sector, and its relevance for macroeconomic fluctuations.

[15] A notable seminal contribution on housing in macoreconomic models is by Davis and Heathcote (2003). The authors construct a growth model with a production and a construction sector and succeed at reproducing important features of U.S. data (namely the positive correlation between consumption, GDP and investment in the two sectors, and the larger volatility of investment in the real estate, compared to capital, sector).

[16] However, note that, in his model, firms are constrained by the value of their real estate holdings, not by that of their assets (capital stock).

where collateral constraints apply to both real estate and capital investment financing and estimate the model with Canadian data. Their analysis provides an empirical validation to the model's ability to reproduce the positive response of consumption to increases in house prices. However, comparing the model with one without collateral constraints, they do not find large differences. The empirical relevance of housing is further confirmed by Pariès and Notarpietro (2008) in a two country model with collateral constraints on housing investment estimated with U.S. and Euro Area data. Furthermore, their analysis of optimal monetary policy in this setting reveals a welfare gain in allowing the central bank to respond to house price movements. The role of developments in the housing market as a driving force of business cycle fluctuations is explored by Iacoviello and Neri (2010) in a model estimated for the U.S. economy, asserting the fit of the model in explaining trends in U.S. housing prices and investment. Furthermore, they find that collateral constraints on household borrowing amplify the response of non-housing consumption. Kannan et al. (2009) reexamine the interplay between house price booms and monetary policy. In particular, they find that a stronger monetary policy reaction to signs of overheating in the economy (i.e. credit growth and house price booms) is successful in dampening the acceleration effect of collateral constraints. Furthermore, they examine the appropriateness of a specific macroprudential policy designed to offset credit developments, and conclude for its usefulness. While these studies largely focused on developed economies, particularly the United States, fewer studies looked at housing developments in emerging economies. Two exceptions are constituted by Brzoza-Brezina and Makarski (2011a) and Ajevskis and Vitola (2011). In the former, a small open economy DSGE model with collateral constraints on housing and capital financing and a banking sector is estimated for Poland, in order to gauge the role played by the banking sector in generating the slowdown during the financial crisis. The second study estimates a small open economy with Latvian data to examine the role of financial intermediation in the business cycle, and the implications for monetary and macroprudential policies.

Only few studies in the literature adopt the asymmetric information framework in introducing financial frictions to mortgage credit (Aoki et al. (2004), Solomon (2010) and Forlati and Lambertini (2011)). Aoki et al. (2004) focus on the implications of credit frictions at the household level for the transmission of monetary shocks. They conclude that the presence of asymmetric information in the credit contract between financial intermediaries and households financing housing purchases amplifies the transmission of changes in the interest rate to housing investment, house prices and consumption. The objective of Forlati and Lambertini's (2011) study is to examine the impact of shocks to mortgage default rates on the macroeconomy, and to evaluate different parametrizations of the central bank's policy rule. They conclude for the superiority of low-inertial rules in stabilizing the economy after an exogenous increase in mortgage defaults. In particular, as inertial rules imply smoother reductions in the nominal interest rate, they imply larger output contractions. Finally, Solomon (2010) examines the interaction between consumer debt and firm debt over the business cycle, focussing on the quantitative importance of feedback effects between the debt levels in the two sectors. His model abstracts from rigidities in price and wage setting, and from monetary policy considerations. His estimation of the model with U.S. data reveals that, while credit frictions at the firm level significantly amplify the response of investment to shocks, they do not amplify output responses. Furthermore, tighter borrowing conditions for households contribute to ease those for firms, leading to a negative co-movement of financial variables across sectors. However, all three studies are set in a closed economy context, and their conclusions are of limited relevance to small, open, dollarized economies. In particular, exchange rate fluctuations have nontrivial consequences for domestic production and prices, thereby influencing consumption and housing demand. Furthermore, balance sheet effects of currency movements at both the household and firm level considerably enrich the dynamics, possibly reverting the monetary policy implications drawn for developed countries. Specifically, Forlati and Lambertini's (2011) prescription for non-inertial rules might be reverted in an open economy context, as large interest rate responses imply exchange rate fluctuations that have large repercussions on trade and balance sheets.

2.4 Credit frictions and capital flows in open economy DSGE models

While the collateral constraint approach of Kiyotaki and Moore has been mainly applied to characterize credit market imperfections in real estate mortgages, the asymmetric information framework by Bernanke, Gertler and Gilchrist (1999) was mainly used in the context of firms' capital financing.

In the context of small, open, emerging market economies, issues as vulnerability to external shocks, limited access to credit and foreign currency borrowing are particularly relevant, and have been incorporated in New Keynesian open economy models framework in order to study their monetary policy implications, with a particular focus on the choice of exchange rate regime. Although the insulating properties of flexible exchange rate regimes have been advocated since the times of Friedman (1953) and Mundell (1960), researchers started to question the validity of this claim in the presence of credit frictions and liability dollarization. While in a non-dollarized economy exchange rate movements affect primarily aggregate demand through a change in relative prices, when debt is denominated in foreign currency an additional balance sheet effect arises[17], which increases the domestic currency value of debt in case of a depreciation, increasing leverage and reducing investment. Therefore, the negative balance sheet effect offsets the expansion of ag-

[17] Krugman (1999), Aghion, Bacchetta, and Banerjee (2001).

gregate demand brought about by the currency depreciation and, if it prevails, it offers an incentive for the central bank to limit exchange rate fluctuations adopting a pegged exchange rate.

Studies in this field largely focus on the impact of negative foreign shocks on the small open dollarized economy. Cespedes, Chiang and Velasco (2004) explore the stabilization properties of fixed and flexible exchange rate regimes in a dynamic general equilibrium model of a small open economy characterized by a financial accelerator and liability dollarization, concluding that, although balance sheet effects magnify the effect of external disturbances, a flexible exchange rate is still successful in insulating the economy from external shocks. The superior stabilization properties of flexible exchange rates are confirmed by Devereux et al. (2006), which subject their small open economy to foreign interest rate and terms of trade shocks. However, their conclusion crucially hinges on the degree of exchange rate pass-through. With high pass-through, stabilizing the exchange rate implies a high trade-off between output and inflation volatility, since it requires a stronger interest rate response; when pass-through is low, exchange rate movements do not have a strong destabilizing effect on the price level and it is better for the central bank to focus on stabilizing inflation, while allowing for the currency to float. In a similar framework, Gertler et al. (2007) explore the issue of whether the exchange rate regime influences a country's response to a financial crisis, defined as an exogenous increase in the country's risk premium. They find that while the financial accelerator amplifies the effect of the shock, it does not alter the ranking between fixed and flexible exchange rate regimes: in particular, they find that the effect of the financial accelerator is more muted with a floating currency. Concerning liability dollarization, they conclude that, although it lowers the attractiveness of a flexible exchange rate, this still leads to a smaller output drop. While these papers treat the foreign economy as exogenous, Batini et al. (2007) study the monetary policy implications of increased degrees of financial frictions and dollarization in a small open economy obtained as the limit case of a two-country DSGE model and characterize the optimal monetary policy in this setting. They conclude that the financial accelerator has a larger impact on the performance of monetary policy rules than the presence of liability dollarization: in particular, targeting the exchange rate is not optimal, as exchange rate movements attenuate the effect of financial frictions.

These studies, however, abstract from three important issues, which I address in Chapter 4. First, they do not consider the housing market and the interplay with financial frictions at the household and firm level. Second, they discard potential financial stability objectives of the small open economy's central bank. Their conclusions concerning the superiority of flexible exchange rate regimes relies on the volatility of output and inflation, without consideration of the volatility of financial variables. Third, they model capital inflow shocks as an exogenous increase in the foreign interest rate or in the country's risk premium. However, the experience of many emerging economies revealed that capital flows are largely influenced by waves of optimism and pessimism of international investors, without any relation to country risk premia or interest rate differentials. Curdia (2006 and 2007) models capital inflows as exogenous shifts in foreign investors' perceptions of domestic borrowers' productivity, in a DSGE setting where financial frictions in the spirit of Bernanke at al. (1999) are introduced on the financing of intermediate goods used for production. In particular, foreign lenders have a distorted perception of borrowers' idiosyncratic productivity and, when they perceive it to be higher, they loosen credit conditions, leading to a decrease in lending rates. As the financial accelerator kicks in, the country experiences a reinforcing spiral of improved lending conditions, rising asset prices and increased net worth, that further lower borrowing costs through a positive effect on leverage. A similar modeling choice is adopted in a series of papers by Ozkan and Unsal (2010, 2011), in order to analyze the transmission of a financial crisis to a small open economy and evaluate monetary policy responses. However, their studies abstract from credit frictions at the household level and financial stability objectives of the monetary authority.

2.5 International financial linkages in DSGE modeling

Models with frictions in credit markets have also been used to explore the role of financial markets in the international transmission of shocks and international business cycle correlations. While increased business cycle co-movement has been observed even when countries are hit by asymmetric shocks, this result does not emerge from traditional open economy models (see for example Gali' and Monacelli (2002)). In fact, in these models the international transmission of shocks happens through international trade and demand switching effects. In a series of papers, Faia (2001, 2002, 2007, 2010) extends the financial accelerator model to a two country framework, and finds that credit frictions enrich the international transmission mechanism with an "indirect financial spillover effect" which can be strong enough to offset the expenditure-switching effect and yield a wide range of business cycle correlations. In particular, Faia (2002) finds that the magnitude of the financial spillover effect increases with the degree of financial similarity between countries, leading to positive business cycle correlation[18]. In a similar framework, Gilchrist (2003) explores the role of financial leverage in the international transmission of shocks. Specifically, he focuses on the transmission of shocks from developed countries (characterized by lower levels of leverage) and developing countries (highly leveraged). His results suggest that, not only slowdowns in economic activity are severely amplified by fi-

[18] In a later paper, Faia (2007) explores the effect of different monetary policy rules (currency union, unilateral peg and inflation targeting) in a similar model with financial differences. She finds that international business cycle synchronization is enhanced in a currency area compared to an independent policy regime. Furthermore, under the unilateral peg, the business cycle co-movements are very close to the ones arising under the currency area.

nancial frictions, but high-leverage economies are particularly vulnerable to external shocks, and that asymmetries between lending conditions across economies provide a strong source of transmission for shocks from developed to developing economies. While this modeling approach offers interesting theoretical insights on the role of financial frictions in altering the international transmission of shocks, it still fails on empirical grounds, to replicate observed business cycle correlations. Alpanda and Aysun (2012) estimate a model in the spirit of Gilchrist (2003) and Faia (2010) with Bayesian methods in order to test its ability to reproduce Euro Area responses to US shocks. They find that the model is able to generate meaningful business cycle correlations only when allowing for correlated shocks across countries.

Extending the framework of an increasing number of studies incorporating a banking sector is standard DSGE models[19] to an open economy setting, a recent strand of literature proved successful in producing models capable of accounting for the observed business cycle correlations and international transmission of country-specific financial shocks. Motivated by the large observed cross-country spillovers of financial shocks during the financial crisis, many studies have appeared embedding international financial linkages in two country models of the New Keynesian paradigm (Mendoza and Quadrini (2009), Davis (2011), Kollmann et al. (2011), Yao (2012), Ueda (2012), Dedola, Karadi and Lombardo (2012)). The key feature of these models is the simultaneous presence of frictions in credit markets, and financial institutions engaged in cross-border lending. In this setting, international credit con-

[19] The recognition of the key importance of the banking sector in originating and propagating shocks led many researchers to model financial intermediation in closed economy DSGE models. A non-exhaustive list of such studies includes Hirakata et al. (2009), Davis (2010), Meh and Moran (2010), Dib (2010), Gerali et al. (2010), Christiano et al. (2010), Gertler and Karadi (2011), Rannenberg (2011). Estimated versions of these models reveal their ability to fit the data (especially financial variables) quite well and that banking sector shocks are important in explaining macroeconomic fluctuations (Hirakata et al (2010), Villa and Yang (2011)).

tracts generate cross-country financial interdependence, as balance sheet conditions of borrowers in one country will affect financial institutions in any country financially linked to it. On one side, international lending consitutes an additional channel through which foreign shocks are transmitted. While in case of financial autarky, say, a foreign monetary policy shock is transmitted internationally to the extent that it alters bilateral exchange rates, relative prices and international demand patterns, in a financially integrated world it has an additional direct effect through its impact on the banking sector and on lending rates in any country borrowing from on the one where the shock originates. On the other hand, modeling financial linkages explicitly allows to study the inter-country transmission of financial shocks, which directly impact other countries through cross-border financial exposures. Adopting different modeling approaches, these studies broadly affirm the importance of cross-country banking exposures in the propagation of country-specific real and financial shocks. Compared to the case of financial autarky, the interdependence of balance sheet conditions resulting from cross-border banking activities yields larger co-movement of business cycles and a stronger spillover of disturbances.

The interplay between financial frictions and exchange rate regimes has so far been studies only in models where cross-border lending relationships are not present. Faia (2010), using a two country DSGE model with financial frictions but no international borrowing, argues for the superiority of a floating exchange rate in isolating a country from foreign shocks. Furthermore, the desirability of a floating currency is enhanced by the presence of financial frictions: not only the output-inflation trade-off is steeper when the currency is pegged, but its intensity increases with the degree of credit frictions.

The analysis presented in Chapter 5 differs from previous studies mainly because it examines exchange rate policy in a world where even country-specific shocks generate positive international business cycle co-movement, obtained by modeling cross-country balance sheet interdependence explicitly. While in the literature analyzing exchange rate regimes in financially dollarized economies the degree of financial dollarization is taken as a proxy of financial interdependence, issues related to international spillovers through direct bank exposure to foreign borrowers are discarded. In a small open economy context, this rules out the analysis of foreign financial shocks, while, in two country models, it limits the transmission of these shocks to real channels. In fact, in this context, the foreign financial shock feeds to the domestic economy only to the extent that changes in foreign investment and output alter international relative prices and demand, and trigger a reaction of the domestic central bank. In a model with explicit financial linkages, a second direct effect is present. A foreign financial shock is directly transmitted to the domestic economy, as domestic banks and lenders are involved in lending contracts with foreign agents. Furthermore, in this setup the exchange rate plays a role in the balance sheets of banks in both countries, giving rise to additional inter-country dynamics.

2.6 Reconsidering the role of monetary policy

Contrary to previous episodes, the undisputed protagonist of the recent global crisis were the financial sector and its underlying instability. One of the most important lessons recent events have taught academics and policymakers is that financial imbalances can arise even in an environment of low inflation and overall macroeconomic stability. In particular, it has been argued that asset price bubbles and excessive credit growth might occur as a consequence of stable inflation expectations and optimistic prospects about the future economic outlook, which encourage risk taking and financial fragility. The crisis led, on one side, to reexamine the appropriateness of the traditional objectives of monetary policy, i.e. inflation and output stability, on the grounds that they might not be necessarily conducive of financial stability. On the other hand, it spurred a debate on the implementation of monetary policy, reconsidering the effectiveness of inflation targeting regimes whereby central banks set the policy rate reacting to inflation and a measure of economic activity. Hence, the dispute on monetary policy conduct in the aftermath of the crisis evolves around two main questions. Should central banks be concerned about financial, in addition to macroeconomic, stability? And, if so, should central banks react to financial variables when setting the monetary policy rate?

On one hand, proponents of the inflation targeting regime argue that, to the extent that asset price inflation and credit growth lead to an expansion of aggregate demand through their effect on wealth and spending, a monetary policy reacting to inflation and output will automatically counteract financial imbalances. The main analytical contribution to this view is offered by Bernanke and Gertler (2001) who use a small scale macroeconomic model to show both theoretically and empirically that, to the extent that central banks react to inflation in the pursuit of price stability, a reaction to changes in asset prices is warranted only as far as they contain useful information about inflationary or deflationary pressures.[20] Of a similar opinion are Bullard and Schaling (2002), who consider a macroeconomic model where the central bank adds asset prices as a target in an otherwise traditional Taylor rule. Their analysis suggests that asset price targeting can interfere with the minimization of inflation and output volatility, leading to suboptimal levels of inflation and the output gap. Faia and Monacelli (2003) focus on the welfare implications of asset prices targeting and dismiss such a monetary policy strategy on the grounds that it is not conducive to higher welfare. The view against asset prices targeting has been widely embraced by central bankers in the United States[21]: in a recent speech, the Philadelphia Fed President Charles Plosser asserted that *"Financial stability should not be an*

[20] A similar conclusion is reached, a few years later, by Distayat (2005). In his model, the nonfundamental component of real asset returns appears in the central bank's optimal monetary policy because it helps to predict future output and inflation dynamics.

[21] See for example Bernanke (2002), Ferguson (2003).

explicit objective of monetary policy per se" and that, in his opinion, *"we need to resist the temptation of adding the financial stability goal to the burdens of monetary policy"*.[22]

On the other hand, proponents of a "leaning against the wind" approach of central banks to inflating asset prices and credit growth argue that output and inflation stability might not be sufficient to induce stable growth in asset prices and credit, with destabilizing consequences on the financial sector and, ultimately, on the real economy. Among the early advocates of this view are Cecchetti et al. (2000), Borio and Lowe (2002 and 2004), Bordo and Jeanne (2002) and White (2006). Their argument rests on the claim that setting monetary policy only considering developments in inflation and the output gap might be a too narrow approach, and that better results in terms of stabilization could be achieved by explicitly targeting unsustainable increases in asset prices and excessive credit growth, even at the cost of increased variability in inflation and output. In particular, it is argued that ensuring a stable path of credit growth is conducive of both financial stability (through reduced swings in asset prices and sustainable leverage dynamics) and macroeconomic stability (hampering excessive fluctuations in consumption and investment). More recently, Curdia and Woodford (2010), use a new Keynesian DSGE model with credit frictions and financial intermediaries to conclude that it is optimal to include a spread adjustment term in the Taylor rule. Woodford (2012) strongly encourages central banks to acknowledge the influence of monetary policy on financial stability, and he argues that the monetary policy trade-off between inflation and financial stability is very similar to that between inflation and output stabilization. In the same way as central banks strike a balance between price stability and output gap stabilization engaging in a so-called "flexible inflation targeting regime", they may very well be able to find a

[22] Speech held in occasion of the American Economic Association Annual Meeting, on January 4th 2013.

short-run path for the economy balancing inflation stability against output gap and financial stabilization. The optimal target criterion resulting from his model reveals that it is appropriate to set the monetary policy instrument to "lean against" a credit boom, even if this requires a temporary sacrifice in terms of inflation and output gap.[23] The validity of a central bank's financial stability objective from a welfare standpoint has been emphasized by Angeloni and Faia (2013). By making a quantitative comparison of welfare under different central bank's objectives, they conclude for the appropriateness of financial stability being included as one of such objectives. Finally, contrary to their American counterparts, European central bankers seem more keen to consider financial stability concerns in their monetary policy conduct and to amend the implementation of monetary policy to include financial variables. In a recent speech at the Czech National Bank, Yves Mersch, a member of the ECB's Executive Board, stated that, although the primary objective of the ECB is to maintain price stability, "*it may be desirable to incorporate in the decision-making process of monetary policy certain financial variables, which, over the medium to longer term, may influence inflationary developments (e.g. excessive credit growth, asset bubbles etc.)*".[24]

How is this debate relevant to emerging economies? Middle income countries can be ascribed characteristics that distinguish them from mature, high income countries. First of all, financial markets are less developed, in particular capital markets. As equity issuance remains limited, firms rely more heavily on bank credit in order to finance their investment projects.[25] Second, emerging economies, and

[23] However, Woodford underlines how his analysis does not imply that financial stability should be the primary responsibility of monetary policy. As his analysis reveals the presence of trade-offs between financial stability and traditional monetary policy objectives, the development of additional tools (i.e. macroprudential policy) is of utmost importance.

[24] Speech by Yves Mersch, member of the Executive Board of the ECB in occasion of the seminar: "Financial Stability Policies in a Post-Crisis World" hel at the Czech National Bank, 4 March 2013. http://www.ecb.int/press/key/date/2013/html/sp130304.en.html

[25] Data on stock market capitalization reveal that, in 2007, the size of Eastern European stock markets

among them particularly Eastern European countries, are heavily financially integrated, which makes them vulnerable to external developments and to international financial cycles.[26] Finally, middle income countries have endured several crises in the past decades, mainly associated with swings in capital inflows, and preceded by the accumulation of large imbalances (currency mismatches, excessive credit growth, asset price inflation). Hence, in this context, it might be worth for monetary authorities to adapt their monetary policy strategy in order to prevent the build up of imbalances, with potentially large effects on welfare. In addition to the pros and cons to financial stability concerns in monetary policy making put forward by the literature[27], some considerations are particularly relevant for emerging economies (Agénor and Pereira da Silva (2011)). On one side, monetary policy might have undesirable side effects in the event of capital inflows which are accompanied by exchange rate appreciations, credit growth and inflationary pressures. In particular, a tightening of monetary policy which increases the interest rate differential of the small open econ-

was much inferior to the average in Euro Area countries. While Estonia, Lithuania, Romania and the Slovak Republic settled on values below 30% of GDP, the average of Bulgaria, the Czech Republic and Poland amounted to 50% of GDP. Only in Slovenia, stock market capitalization reached a value as high as 60% of GDP. In comparison, the average of Euro Aerea countries exceeded 80% of GDP (Pirovano et al. (2011)).

[26] As reported by Lane and Milesi-Ferretti (2007), the degree of international financial integration measured through the capital account of the Central and Eastern European economies has doubled since the beginning of the transition process. The sum of external assets and liabilities as a percentage of GDP was on average 80% in 1994 and rose to 160% by 2004.

[27] The arguments opposing the inclusion of financial stability considerations in monetary policy's objectives and implementation relate mainly to the adequacy of the short-term interest rate in dealing with financial imbalances. It is argued, first, that multiple objectives call for multiple instruments (the Tinbergen principle) and, second, that macroeconomic and financial stability necessarily imply a trade-off for the central bank. Third, reacting to financial variables might induce too large swings in the monetary policy rate exerting a destabilizing effect on the real economy. The case for a more proactive role of monetary policy in pursuit of financial stability objectives rests on the following arguments. First, if monetary policy had not been so accommodative before the crisis and took leverage and credit developments into account, it could have mitigated the impact of the crisis. Second, monetary policy might be very effective in deflating credit-financed bubbles. Third, macroprudential policy as implemented before the crisis did not prove to be very successful. For a thorough review of the arguments in favor and against financial consideration in monetary policy conduct, see Kohn (2006) and Agénor and Pereira da Silva (2011).

omy might reinforce the capital inflow. In this circumstance, countercyclical policies such as capital controls might be a more suitable alternative. On the other hand, relying too heavily on macroprudential regulation by limiting credit availability and increasing borrowing costs might encourage the shadow banking sector, making it even more difficult to maintain financial stability. Furthermore, as confirmed by the recent experience, in the run-up to a financial crisis both macroeconomic and financial instability increase, justifying a preemptive intervention of the central bank in normal times to offset the growing financial vulnerability.

CHAPTER 3
MONETARY POLICY AND STOCK PRICES IN SMALL OPEN ECONOMIES: EMPIRICAL EVIDENCE FOR THE NEW EU MEMBER STATES

This chapter focuses on the interplay between financial integration, monetary policy and stock prices in four NMS, namely the Czech Republic, Hungary, Poland and Slovenia.[28] Given the significant body of studies pointing towards a significantly inverse relationship between short-term interest rates and stock prices in advanced economies, in this chapter I assess whether this finding holds also for small economies characterized by tight trade and financial linkages with larger countries. The tight trade relationships and heavy dependence of the NMS on loans originating in Euro Area countries leads to assume that cash flows of NMS's firms, and hence stock prices, might be increasingly influenced by Euro Area monetary policy.

According to the well-known present value model, the current price of a stock is defined as the discounted value of the stream of future expected cash flow. From this simple model it emerges that monetary policy can influence stock prices in two ways. A first, direct effect is on the discount rate, if discount rates are tied to market rates, which the Central Bank is able to influence. Secondly, monetary policy affects expectations of future cash flow. A rise in the interest rate implies a higher cost of investment, which in turn decreases expected future cash flow, leading to lower stock prices. In turn, stock prices affect the real economy by influencing financial wealth, and with it consumption and investment decisions. The two effects operate in the same direction: a contractionary monetary policy action, i.e. an increase in the policy rate, increases the discount rate and reduces expected future cash flow, implying a de-

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crease in stock prices. However, in economies characterized by high degrees of trade and financial openness, foreign interest rates (especially the one of the country they are mostly tied to) might have important effects on stock prices. First, movements in borrowing and exchange rates, and demand effects can affect firms' performance. As an example, anappreciation of the foreign currency due to a tightening of the foreign monetary policy stance increases the cost of imported intermediate goods and decreases output of firms in CEECs, exerting a negative effect on stock prices. Furthermore, for firms relying on foreign funding, an increase in foreign interest rates translates in a raise in borrowing costs, making it more difficult to service existing loans and more expensive to contract new ones. In addition, demand effects of contractionary monetary policy in the EA reduce demand for NMS' exports if quantity effects dominate the consumption switching effect of CEECs' exchange rate depreciation. Finally, as interest rate differentials increase, investors might rebalance their investment portfolios.

This chapter deals with three main issues. First, I examine the effect of domestic monetary policy on stock prices in the NMS, an issue not investigated so far. While monetary policy shocks are passed through the real economy with considerable delay, financial markets are much more reactive, in that asset prices tend to quickly incorporate new information. Secondly, in light of the heavy financial linkages between the NMS and the Eurozone, I examine the response of the domestic stock market to Euro Area monetary policy shocks. Thirdly, I determine which domestic and foreign variables are the main drivers of stock price movements in the countries under analysis.

The methodology is rather standard. I estimate a macro-econometric model of a small open economy using monthly observations on seven macroeconomic variables for the Czech Republic, Hungary, Poland and Slovenia. I identify the structural

VARs by means of short-run restrictions following Neri (2004), Jarocinsky (2008) and Li, Iscan and Xu (2010) and examine impulse-response functions and forecast error variance decompositions. The study is structured as follows. Section 3.1 presents the baseline SVAR model, the identification scheme and the resulting equations. In section 3.2 reports the results, after describing the dataset and testing for model adequacy. I assess the robustness of our results to alternative identification schemes in section 3.3. Section 3.4 concludes and proposes directions for further research.

3.1 The baseline model

The analysis is based on the identification and estimation of a Structural Vector Autoregressive (SVAR) model. SVARs are extensively used in macroeconomic analysis and particularly in monetary economics, in order to analyze the effect of exogenous shocks in monetary policy on macroeconomic variables. One of the toughest challenges of modeling monetary policy is to distinguish between monetary policy actions that the market has already anticipated and those it has not. If we accept the rational expectations hypothesis, anticipated monetary policy changes will already be embedded in the current stock prices, while only unanticipated actions will have an effect on current returns. In this context, the VAR framework is the most adequate.

The starting point of the analysis is a VAR model without exogenous variables[29], whose reduced form is:

$$x_t = \Gamma_0 + \Gamma_1 x_{t-1} + \Gamma_2 x_{t-2} + ... + \Gamma_p x_{t-p} + u_t \tag{3.1}$$

Where x_t is a $(n \times 1)$ vector of the n endogenous variables included in the VAR (in our case n = 7), $x_{t-1}, ..., x_{t-p}$ are $(n \times 1)$ vectors of the lagged values of

[29] In the present context, it might have been useful including exogenous foreign variables in order to control for external developments in the Euro Area economy and stock market. Nevertheless, these variables are correlated with the Euro Area short-term interest rate, thereby violating the exogeneity requirement.

the endogenous variables, $\Gamma_1, ..., \Gamma_p$ are $(n \times n)$ coefficient matrices, Γ_0 is a $(n \times 1)$ vector of constant terms and u_t is a $(n \times 1)$vector of white noise disturbances, with $E(u_t) = 0$ and variance-covariance matrix $E(u_t u_t') = \Sigma_u$.

As the components of u_t may be instantaneously correlated (i.e. the matrix Σ_u may be not diagonal), the impulse responses obtained from the reduced form model might not properly reflect the relations between the variables.

In order to consider a model with uncorrelated residuals, we can model the instantaneous relationships between variables directly. In particular, if the reduced form disturbances are linear combinations of the structural shocks (ε_t) in the form $Bu_t = \varepsilon_t$, we can define the following structural model:

$$Bx_t = A_0 + A_1 x_{t-1} + A_2 x_{t-2} + ... + A_p x_{t-p} + \varepsilon_t \tag{3.2}$$

Where x_t is again our $(n \times 1)$ vector of the n endogenous variables at time

t, $A_0 = B\Gamma_0$ is a vector of constants, $A_1 = B\Gamma_1, ..., A_p = B\Gamma_p$ are matrices of coefficients of the p lagged values of all endogenous variables and $\varepsilon_t = Bu_t$, where $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_t') = B\Sigma_u B'$. Hence, for a proper choice of B, the variance-covariance matrix of the structural innovations will be diagonal.

The reduced form model in equation (3.1) has $N^2 p + N + (N(N+1))/2$ parameters to be estimated: $N^2 p + N$ in the equation for x_t and $(N(N+1))/2$ unique elements in the covariance matrix. The structural form of equation (3.2) has $2N + N^2 p$ unknown parameters, which is smaller than $N^2 p + N + (N(N+1))/2$. It is therefore necessary to impose restrictions on the reduced form model in order to identify the primitive system. In particular, given estimates of the u_ts, I will identify the structural shocks imposing suitable, economically meaningful restrictions on the B matrix of contemporaneous coefficients.[30] The seven variables in our model are,

[30] Alternatively, we could restrict the reduced form model by means of the so-called Choleski de-

in order: the Euro Area interest rate (EAint), the nominal exchange rate vis-à-vis the euro (er),[31] the industrial production index (ip), the domestic price level (cpi), the domestic short-term interest rate (i), the monetary aggregate M2 (m) and the stock market index (smi).[32]

In order to identify the structural shocks I impose short-run restrictions on the B matrix following Neri (2004) and Li, Iscan and Xu (2010). As a result, the long-run behavior of the model is left completely unconstrained.

The following relation between the reduced and the structural error terms is proposed:

$$\begin{pmatrix} \varepsilon_{EAint} \\ \varepsilon_{er} \\ \varepsilon_{ip} \\ \varepsilon_{cpi} \\ \varepsilon_{i} \\ \varepsilon_{m} \\ \varepsilon_{gmi} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ -b_{31} & -b_{32} & 1 & 0 & 0 & 0 & 0 \\ -b_{41} & -b_{42} & -b_{43} & 1 & 0 & 0 & 0 \\ 0 & -b_{52} & 0 & 0 & 1 & -b_{56} & 0 \\ 0 & 0 & -b_{63} & -b_{64} & -b_{65} & 1 & 0 \\ -b_{71} & -b_{72} & -b_{73} & -b_{74} & -b_{75} & -b_{76} & 1 \end{pmatrix} \begin{pmatrix} u_{EAint} \\ u_{er} \\ u_{ip} \\ u_{cpi} \\ u_{i} \\ u_{m} \\ u_{gmi} \end{pmatrix} \tag{3.3}$$

In particular, I set the diagonal elements of the B matrix to unity as this allows writing the $k-th$ equation of the model with $x_{k,t}$ on the left-hand side.

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composition, which consists in restricting the covariance matrix of the reduced form residuals to be a lower-triangular matrix and which leads to a just-identified model (i.e. a model with as many restrictions as there need to be). Although it is handy from a practical point of view, the Choleski decomposition imposes restrictions without a theoretical foundation; moreover, it imposes an ordering to the variables in the VAR which might or might not be appropriate. Hence, if there is not a theoretical basis to impose such restrictions, the impulse-responses might be poorly identified. We will impose a Choleski type of identification as a sensitivity check (cfr. section 5).We refer to Enders (2004) for a detailed description of the different ways to impose restrictions on the reduced form model and their criticism.

31 Defined as the price of foreign currency (euro) in terms of domestic currency.

32 Data on the consumer price index, industrial production index and the monetary aggregate (money + quasi-money) are from the IMF's International Financial Statistics. Data on exchange rates, the money market rate (except for Hungary, where the T-bill rate is used) and the stock market index are from Eurostat. All variables except the short-term interest rate and the Euro Area interest rate are in logarithms.

The money supply equation is a feedback rule according to which the Central Bank sets the short-term interest rate. I assume that, when setting the monetary policy instrument, the Central Bank does not observe the current values of real output and the price level, which are observable only after a lag.[33] Hence, the interest rate is defined as dependent on contemporaneous values of the exchange rate and the monetary aggregate, and on lagged values of the other variables in the model (embedded in the term $h\left(x_{t-p}\right)$), as follows:

$$i_t = b_{50} + b_{52} er_t + b_{56} m_t + h(x_{t-p}) + \varepsilon_{t,i} \tag{3.4}$$

In particular, I expect the coefficient b_{52} to be positive: a depreciation of the exchange rate (increase in er_t) causes imports from abroad to be more expensive, hence resulting in inflationary pressures. The Central Bank is then supposed to react by tightening monetary policy. The inclusion of the exchange rate in the Central Bank's reaction function is motivated by the choice of exchange rate regime in the NMS. Although in the late 1990s many countries opted for flexible regimes, their Central Banks tried to keep the domestic currency to fluctuate too much. In most recent years, while Poland adopted a free floating regime, the other countries opted for less flexible alternatives: while Hungary and Slovenia pegged their currencies to the euro with large fluctuation bands, the Czech Republic adopted a managed floating regime with the euro as a reference currency (Maria-Dolores, 2008). It is therefore reasonable to assume that these countries have been following, although not as their primary objective, some form of exchange rate targeting. The last term in equation (3.4) represents an exogenous shift in monetary policy: a positive (negative) shock to the short-term interest rate results in an unexpected tightening (relaxing) of monetary policy.

[33] A similar specification is adopted by Li, Iscan and Xu (2010). This assumption is reasonable in light of the monthly frequency of our dataset, but will be relaxed as a robustness check.

The equation representing equilibrium on the money market is a pretty standard one, linking the monetary aggregate to output, the price level and the interest rate. The resulting LM-type equation is the following:

$$m_t = b_{60} + b_{63} ip_t + b_{64} cpi_t + b_{65} i_t + h(x_{t-p}) + \varepsilon_{t,m} \tag{3.5}$$

Where a negative relationship in the (m, int) space is expected. $\varepsilon_{t,m}$ is an exogenous shock in the demand of money. The equation for the aggregate supply is specified as follows:

$$ip_t = b_{30} + b_{31} EAint_t + b_{32} er_t + h(x_{t-p}) + \varepsilon_{t,ip} \tag{3.6}$$

Equation (3.6) states that industrial production in our model is influenced by contemporaneous values of the Euro Area interest rate and the bilateral exchange rate with the euro, as well as an exogenous aggregate supply shock ($\varepsilon_{t,ip}$)., which can be interpreted as a productivity shock or a cost push shock. The proposed specification of the equation for industrial production is motivated by two considerations. First, the Euro Area interest rate enters the equation in reason of the heavy presence of foreign investors in the NMS[34], which leads us to assume that changes in the foreign interest rate will have an impact on the capital stock of domestic firms. Furthermore, as firms rely on foreign borrowing to finance their capital stock (see Rosenberg and Tirpak (2008) on private sector foreign borrowing in the new EU member states), an

[34] Since the beginning of the transition process, the Central and Eastern European countries caught the interest of foreign investors. The last two decades saw a marked increase in the stock of foreign direct investment (FDI) in the region. While in 1990, the stock of FDI constituted a negligible share of GDP (1.5% in Hungary and 0.2% in Poland), ten years later it accounted, on average, for 30% of GDP (38.2% in the Czech Republic, 47.7% in Hungary, 20% in Poland and 14.8% in Slovenia and, by 2007, it had increased by 50%, reaching 57.7% of GDP in the Czech Republic, 70.5% in Hungary, 33.8% in Poland and 22.5% in Slovenia (UNCTAD, 2008). While the manufacturing sector attracted 65% of total FDI in the region in the first decade after the fall of the Berlin Wall (see Resmini (2000)), in most recent years foreign investors diverted their attention towards the services sector, which comprised around 55% of total FDI in the period 1998-2003 (ECB, 2010). FDI is highly beneficial for capital formation in Central and Eastern Europe: Krkoska (2001) estimates that a 1% increase in Foreign direct investment leads to a 0.7% increase in capital formation.

increase in the foreign interest rate represents an increase in their production costs. Second, the bilateral exchange rate enters the equation in reason of the importance of imported intermediate goods in production. Empirical estimates by Reininger (2007) assess the prominent role of fixed investment in determining import demand in the new EU member states. A depreciation of the domestic currency represents an increase in marginal cost for firms relying on imported inputs, thereby negatively affecting production.

Following Li, Iscan and Xu (2010), aggregate demand is divided in domestic and external demand. Domestic demand is defined in terms of the factors affecting the domestic price level, as follows:

$$cpi_t = b_{40} + b_{41}EAint_t + b_{42}er_t + b_{43}ip_t + h(x_{t-p}) + \varepsilon_{t,cpi} \tag{3.7}$$

Where I assume a certain degree of price stickiness reflected in the coefficient b_{43}. The error term represents exogenous demand shocks, e.g. an exogenous change in preferences. External demand is defined by the exchange rate equation. I define the exchange rate as being conditional only on contemporaneous values of the foreign interest rate and lagged values of all other variables in the model. This approach differs from Li, Iscan and Xu (2010) in that they consider the exchange rate market to be strongly efficient, i.e. incorporating all publicly and privately available information. In their model, the exchange rate is dependent on the contemporaneous values of real output, the domestic price level, the monetary aggregate, the short-term interest rate and the foreign interest rate.[35] I adopt a different approach, by modeling the exchange rate equation as:

$$er_t = b_{20} + b_{21}EAint_t + h(x_{t-p}) + \varepsilon_{t,er} \tag{3.8}$$

[35] This alternative will be explored as a robustness check.

We motivate this specification mainly because of the large, short-term and interest-sensitive capital inflows which are typical of the region.[36] I hypothesize that a contemporaneous shift in the foreign interest rate and hence a change in the interest rate differential produces capital flows that put pressures on the value of the currency. The stock price equation is left completely unrestricted. This implies that the stock price index at time t is influenced by contemporaneous and lagged values of all the variables in the model, plus an exogenous shock, which we can interpret as an exogenous shock in the demand for domestic equities. The rationale for this model approach stems from two considerations. First, according to the efficient market hypothesis, stock prices at a given time reflect all available information. Given stock markets' quick receptiveness of new information and the monthly frequency of our dataset, I assume that the stock price at any point in time incorporates past and present information on all real and financial variables available to the agents. Second, as the stock price index is the variable of interest of our analysis, I do not want to impose any a priori restriction on its responsiveness to other variables in the model. Finally, the foreign interest rate is a contemporaneously exogenous variable.[37]

3.2 Data and estimation results

3.2.1 Dataset and preliminary analysis

The SVAR model is estimated using data for the Czech Republic, Hungary, Poland and Slovenia. I exclude the Baltic States and Bulgaria because they adopted a strictly

[36] The new and potential EU countries have experienced episodes of large capital inflows since the beginning of the transition process (Cardarelli et al. (2010)). While during the 1990s foreign direct investment was the pre-eminent form of foreign investment, since the mid 2000s short-term capital inflows in the form of cross-border loans became predominant (Pirovano, Vanneste and Van Poeck, 2011). Furthermore, as noted by Lane and Milesi-Ferretti (2007), Western European countries are the main financial trading partner of the NMS and most of the transactions are denominated in euro.

[37] While in principle the foreign interest rate should be modeled as strictly exogenous, such an approach wouldn't allow to examine the responses of the endogenous variables to shocks in Euro Area monetary policy.

fixed exchange rate regime for most of the sample period.[38] While in the beginning of the transition period also the Czech Republic, Hungary and Poland operated under fixed exchange rate regimes, from the late 1990s they opted for more flexible systems. The Czech Republic operates under a managed float since 1997, with a brief interruption in 2001 and 2002, when it adopted an independent floating regime. Hungary adopted a crawling band system in 1995, increased flexibility adopting a managed float in 2001 and switched to a pegged regime with large fluctuation bands in 2003. Only recently, in 2008, it reverted to a flexible regime. Poland shifted from a crawling band (from 1995 to 1999) to an independent float. Finally, Slovenia operated under a managed float until 2004, when, in order to join ERM II, pegged its currency to the Euro with large fluctuation bands. (Maria-Dolores (2009))

Furthermore, following Jarocinski (2008) I exclude Romania and Slovakia because for a large part of the sample they exhibit a discrepancy between the central bank rate and the money market rate: in particular, the latter moves independently from the former. One of our main assumptions (cfr. section 2) is that the Central Bank is able to influence money market rates, and in these countries it is clearly violated. The sample period differs slightly for each country: from January 1998 to August 2009 for the Czech Republic (140 observations), from April 1995 to August 2009 for Hungary (173 observations), from May 1995 to July 2009 for Poland (171 observations) and from May 1997 to October 2005[39] for Slovenia (106 observations).

Before estimating the model, I perform a battery of tests to check for the adequacy of the baseline model. Although some variables exhibit evidence of non-stationary behavior (cfr. Table 3.2 in the appendix) and the Trace and Maximum

[38] Lithuania and Bulgaria are currently operating under a currency board on the euro (previously on the Deutsche Mark or the US Dollar), as did Estonia before joining the Euro in 2011; Latvia settled on a fixed peg on the DST and on the euro since 2005.

[39] The sample for Slovenia is limited due to the lack of data on the monetary aggregate from October 2005 onwards.

Eigenvalue tests find evidence of cointegration (cfr. Table 3.3 in the appendix), the SVAR model is specified in levels of the variables without imposing cointegrating relationships. This choice is dictated by three considerations. First, there is uncertainty about the number of cointegrating relationships. Table 3.3 shows that the order of integration changes when the tests are performed on a VAR including the integrated variables only rather than the entire set of variables. Hence, I avoid possible misspecification errors due to imposing long-run relationships not supported by theoretical underpinnings. Secondly, I avoid first differencing the nonstationary variables as this would amount to ignoring error correction mechanisms and important correlations in the data (Lutkepohl and Krätzig (2004)). Thirdly, our choice of estimating the model in levels does not impair the quality of our results. In fact, the estimates of the parameters that characterize the dynamics of the system are consistent when estimating the VAR in levels implying that, asymptotically, the impulse-responses from the model in levels will coincide with the ones resulting from a vector error correction specification (Hamilton (1994)). Furthermore, Sims et al. (1990) show that the distributions of the statistics of interest to conduct standard inference in a multiple time series context are not affected by nonstationarity in some series.[40]The choice of specifying the model in terms of levels of the variables comes at the cost of a slight loss in efficiency of the estimators, but allows us to avoid possible misspecification errors and still yields consistent estimates.[41]

We determine the optimal lag length of our models by means of the AIC, FPE, HQIC and SBIC information criteria. In particular, I look for the number of lags that minimizes these criteria. It is important to note that while the AIC tends to overestimate the number of lags, under fairly general conditions the HQ and SC criteria

[40] For a detailed discussion on how to make inference when series are likely characterized by unit roots, we refer the interested reader to Sims and Uhlig (1991) and Phillips (1991).

[41] Bagliano and Favero (1998), Neri (2004), Li, Iscan and Xu (2010) and Koivu (2011) similarly estimate models in levels.

estimate the correct number of lags (Lütkepohl (2006)). This procedure leads us to obtain a different number of lags for the models of the different countries, as summarized in Table 3.4. While for Hungary and Slovenia the 2 lags suggested by the test statistics are sufficient to yield a correctly specified model, for the Czech Republic and Poland I decide to include a number of lags equal to 4. Indeed, for these countries the inclusion of fewer lags results in a large amount of residual autocorrelation. In order to evaluate the adequacy of the variables included in the models, I estimate the unrestricted model for each country excluding, in turn, the Euro Area interest rate, the bilateral exchange rate and the stock market index. In all cases and for all countries, the specification including the whole set of seven variables performs better, as measured by the AIC and SBC.[42] Finally, I check for stability of our VAR models, by computing the roots of the characteristic polynomial: despite some roots are close to one, formal testing reveals that none of them lies outside the unit circle, and our VARs are stable.[43] Given that formal testing confirmed our model specification, I proceed with the estimation of the baseline model. While the test for overidentifying restrictions confirmed the validity of the imposed identification scheme in the models for Poland and Slovenia, the baseline specification was rejected for the Czech Republic and Hungary. Hence, in these models, I had to drop one overidentifying restriction: specifically, in these models, coefficient b_{54} is not restricted to be equal to zero. This leads to a specification of the monetary policy rule (cfr. equation 3.4) where the Central Bank is able to observe the current price level and incorporate this information in the monetary policy reaction function. The overidentifying restriction tests for this alternative specification do not reject the null that the overidentifying restrictions are valid **(**cfr**.** Table 3.5**).**

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[42] Results are not reported for space reasons.

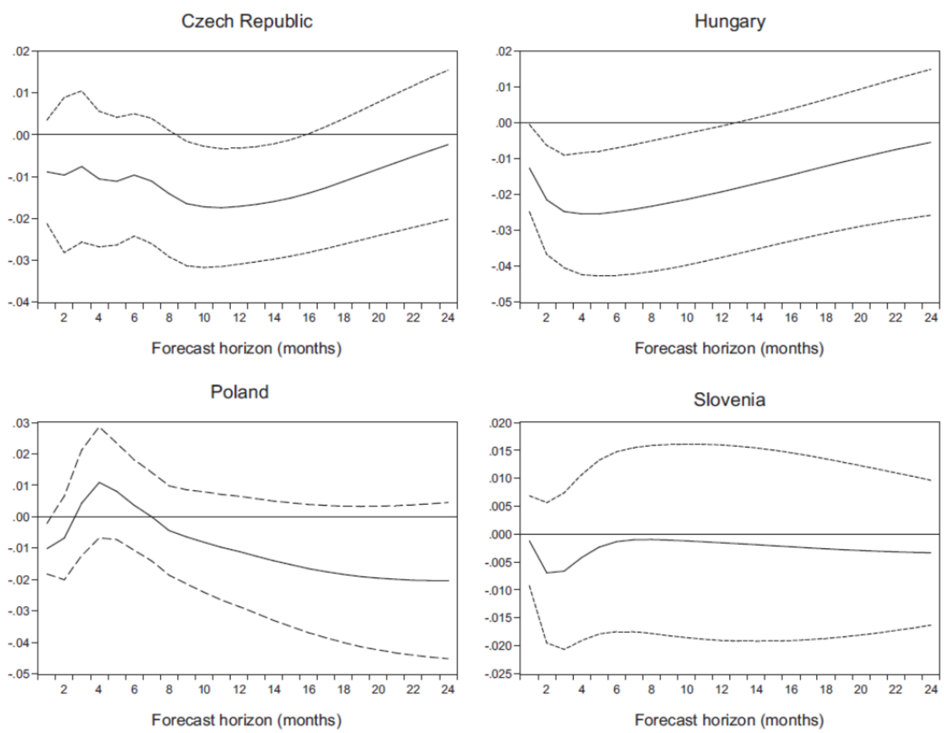
[43] Cfr Figure 3.7 in the Appendix.

3.2.2 Impulse-response functions

In this section, I examine the impulse-response functions and the variance decompositions obtained imposing the baseline structural identification scheme.

As our interest lies in the analysis of the impact of monetary policy on stock prices, I first examine the responses of the stock price index to a one standard deviation structural innovation to domestic and Euro Area monetary policies. Figure 3.1 depicts the responses of the stock price indices of the four countries to a contractionary, one standard deviation shock to domestic monetary policy, i.e. an increase in the domestic interest rate. The estimated responses are plotted for a forecast horizon of 24 months. As expected, a contractionary monetary policy shock causes a decrease in the stock price index in all countries, albeit with some differences. The impact effect is negative in all countries, but heterogeneities arise in the dynamics and in the statistical significance of the estimated responses. Except Slovenia, which exhibits an impact effect very close to zero, impact effects lie in a close neighborhood of -0.01 (albeit in the Czech Republic it is not significant). Moreover, the estimated responses remain negative for the rest of the time horizon, showing a tendency to revert towards the pre-shock equilibrium. Only in the Poland the estimated response becomes positive between the second and the seventh month after the shock, but not significantly in statistical terms.

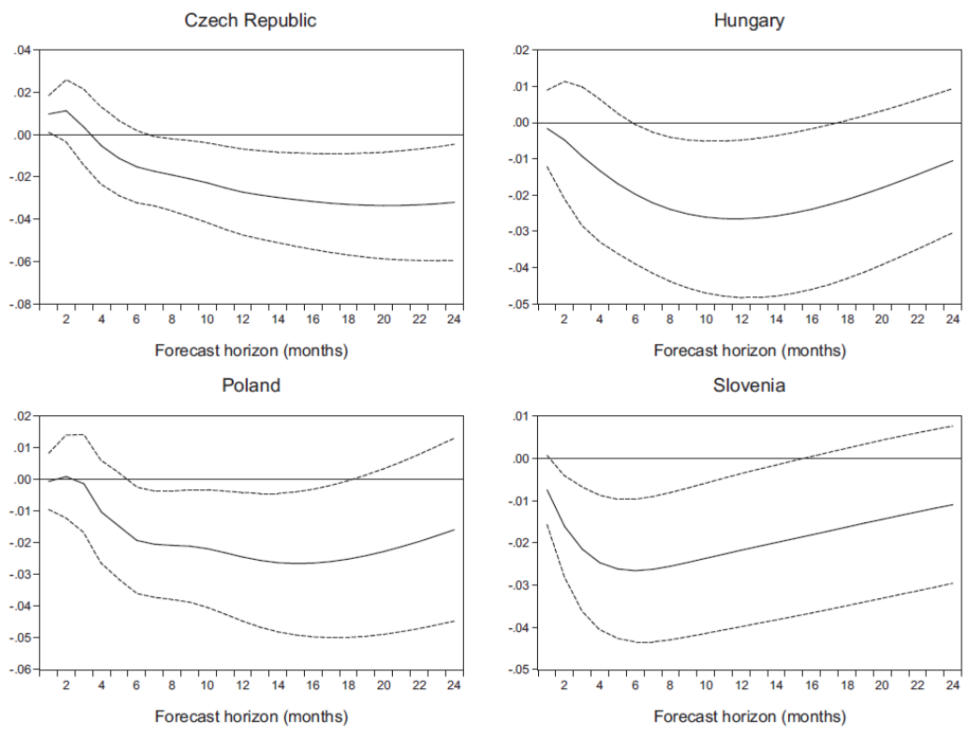
Figure 3.1: Responses of the stock price index to a +1 standard deviation innovation to the domestic interest rate (± 2 standard errors).



In Hungary, the negative response is negative and statistically significant until the thirteenth month after the shock, while in the in the Czech Republic the negative response of the stock price index becomes statistically significant only 8 months after the shock, and it reaches a peak at the 10th month after the shock (-0.017). In Hungary the negative peak is reached much sooner (5 months after the shock) and it is slightly more pronounced (-0.025). Moreover, the dynamic adjustment towards the pre-shock equilibrium is smooth, signaling a high degree of persistence. The reaction of the stock price index in Poland and Slovenia is not statistically significant during the entire forecast horizon.

Figure 3.2 represents the responses of the stock price index to a one standard deviation increase in the Euro Area interest rate. A first glance suffices to see an overall negative effect and a high degree of similarity between countries.

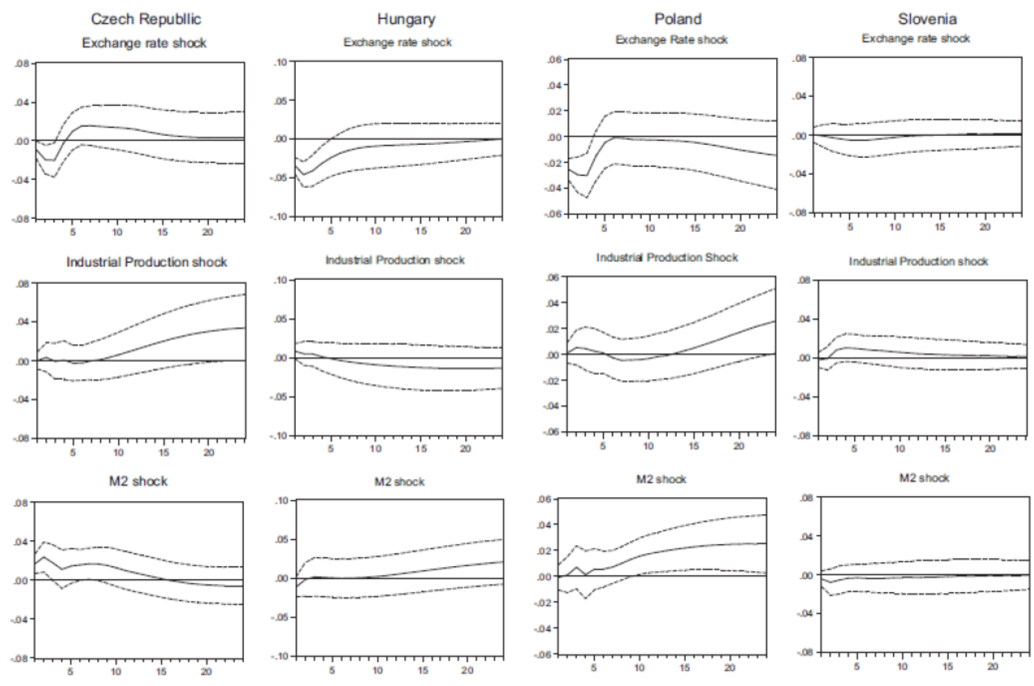
Figure 3.2: Responses of the stock price index to a +1 standard deviation innovation to the Euro Area interest rate (± 2 standard errors).



The largest and statistically significant impact effect is registered in Slovenia (-0.01), followed by a further decline in the stock price index until a negative peak of -0.026 is reached 7 months after the shock. Note how the persistence of this shock is much higher than in the case of a domestic monetary policy shock: here, the stock price index does not revert to its pre-shock level within 2 years after the shock. The impact effect in Hungary and Poland is very small and not statistically significant, but it becomes larger and significant in later months, signaling that a shock in the foreign interest rate is not immediately transmitted to the domestic economies. While in Hungary a negative peak (-0.026) is reached a year after the shock, in Poland it is reached after 16 months. The dynamic response of the Czech stock price index stands out from the group in that the impact effect of a rise in the foreign interest rate is positive and statistically significant. Nevertheless, from the 3rd month onwards it starts decreasing and it becomes significantly negative from the 7th month onwards.

In figure 3.3, I report the dynamic responses of the stock price index to shocks to other variables in the model.

Figure 3.3: Responses of the stock price index to a +1 standard deviation innovation to the exchange rate, industrial production and M2 ($\pm$ 2 standard errors)



The first row of figure 3.3 depicts the responses of the stock price index to an unexpected increase in the exchange rate, i.e. a depreciation of the domestic currency. The estimated response is significantly negative at a short time horizon in all countries except Slovenia, where the response is very weak and not significant. Being small open economies, an unexpected change in the exchange rate could have two roots. First, it could be given by a sudden stop in capital inflows, which puts downward pressure on the exchange rate. The decrease in demand for domestic capital, including domestic stocks, causes their prices to decrease to re-establish equilibrium on the market. Second, an unexpected depreciation might be triggered by an unexpected decline in the foreign demand of domestic goods, which depresses production and expectations of future cash flow.[44] The second row of figure 3.3 depicts the responses of the stock price index to a positive shock in industrial production. Our expectation of a significant increase in stock prices is not confirmed. In all countries, the estimated response is not statistically significant, and very small in magnitude. A similar conclusion holds for the responses to a money demand shock, presented in the last row of figure 3.3. Only in the Czech Republic a positive shock to M2 significantly increases stock prices.

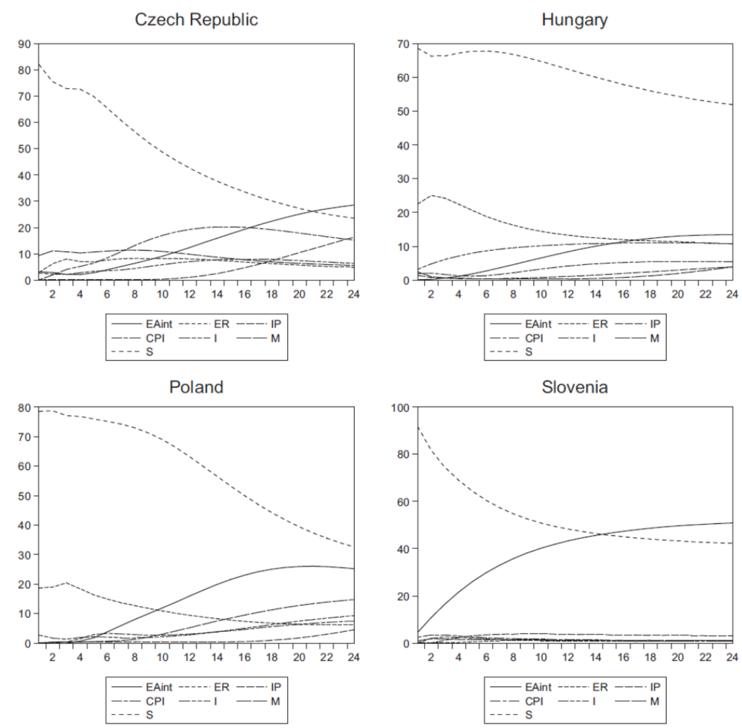
3.2.3 Innovation Accounting

In this section, I analyze the contribution of the seven variables in the model to fluctuations in the variability of the stock price index by means of variance decomposition. In Figure 3.4, the total variation in the stock price index is decomposed in shares ascribed to the single shocks in the model, for a time horizon of 24 months. As it is to be expected, shocks to the stock price index itself account for the largest fraction of the variation. Nevertheless, important considerations stem from the observation of the contributions of the other six variables. First of all, it is immediately possible to notice substantial differences across countries. Secondly, it is evident that it is important to make a distinction between the short and the long-run in that shocks that

[44] See also Li, Iscan and Liu (2010).

do not contribute much to the variation in stock prices on impact, gain importance in the medium to long term. In the Czech Republic, shocks to the monetary base and the exchange rate account for the largest fraction of variation in stock prices while losing importance later on in the time horizon, and being outperformed by the Euro Area and the domestic interest rates.

Figure 3.4: Variance decomposition of the stock price index.



In Hungary and Poland, the exchange rate accounts for the largest fraction of variation of stock prices on impact and in the short to medium term: 23% and 19% respectively. In Hungary, the domestic interest rate comes right after the exchange rate: although on impact its contribution is around 4%, it increases in the medium-run and it stabilizes around 10%. In Poland, both the domestic and the foreign interest rates contribute to the variation of stock prices quite insignificantly on impact: nevertheless, the Euro Area interest rate becomes increasingly important and in the medium-run, it accounts for more than 20% of the total variation. The picture for Slovenia is quite different from the previous ones. Here, the Euro Area interest rate dominates the scene: although on impact it accounts for only 5% of the total variation, already after 4 months it reaches 20% and keeps on increasing with time. All other variables have a negligible impact. These figures reinforce our previous conclusion according to which increasing financial openness has an impact on stock prices in the NMS. Moreover, it emerges that domestic stock prices are more sensitive to external developments than domestic ones. This can be explained by the heavy presence of foreign investors in the stock markets of the new EU members.

3.3 Robustness check

In what follows I check the robustness of our results to four alternative model specifications. Table 3.1 provides a summary of the alternative specifications estimated in this section.

The first alternative differs from the baseline in the specification of the monetary policy rule. While in the baseline specification I assumed that the Central Bank does not react to contemporaneous values of output and the price level, I now relax this assumption and estimate coefficients b_{53} and b_{54}. In the second specification, I relax the hypothesis according to which the nominal exchange rate is contemporaneously influenced only by the Euro Area interest rate. I now assume that the exchange rate market is efficient, in the sense that it incorporates all available information: the contemporaneous coefficients of output, the price level, the domestic interest rate and the money stock are now left unrestricted, as we can read in the second line of Table 3.1. As the exchange rate is contemporaneously affected by the contemporaneous values of all other variables in the model except the stock price index, its position

Table 3.1: Alternative specifications

Alternative 1	$i_t = b_{50} + b_{52}er_t + b_{53}ip_t + b_{54}cpi_t + b_{56}m_t + \epsilon_{t,i}$	$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ -b_{31} & -b_{32} & 1 & 0 & 0 & 0 & 0 \\ -b_{41} & -b_{42} & -b_{43} & 1 & 0 & 0 & 0 \\ 0 & -b_{52} & -b_{53} & -b_{54} & 1 & -b_{56} & 0 \\ 0 & 0 & -b_{63} & -b_{64} & -b_{65} & 1 & 0 \\ -b_{71} & -b_{72} & -b_{73} & -b_{74} & -b_{75} & -b_{76} & 1 \end{pmatrix} \begin{pmatrix} EAint \\ er \\ ip \\ cpi \\ i \\ m \\ smi \end{pmatrix}$
Alternative 2	$er_t = b_{20} + b_{21}EAint_t + b_{23}ip_t + b_{24}cpi_t + b_{25}i_t + b_{26}m_t + \epsilon_{t,er}$	$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ -b_{31} & -b_{32} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & -b_{45} & -b_{46} & 0 \\ 0 & -b_{52} & 1 & -b_{54} & 1 & 0 & 0 \\ -b_{61} & -b_{62} & -b_{63} & -b_{64} & -b_{65} & 1 & 0 \\ -b_{71} & -b_{72} & -b_{73} & -b_{74} & -b_{75} & -b_{76} & 1 \end{pmatrix} \begin{pmatrix} EAint \\ ip \\ cpi \\ i \\ m \\ er \\ smi \end{pmatrix}$
Alternative 3	Cholesky decomposition 1	Ordering of the variables as in the baseline model
Alternative 4	Cholesky decomposition 2	Ordering of the variables as in Alternative 2

in the ordering of the variables in the model changes, and it now correspond to the sixth row of the B matrix. As one of the main criticism to VAR models is their susceptibility to different variable ordering, it is useful to check whether our results are robust to a change in the order of the variables. As this alternative formulation of the exchange rate equation amounts to the elimination of four restrictions, I impose an additional restriction in order to give more structure to the model. In particular, in the money market equilibrium equation I constrain coefficient b_{53} to be equal to minus one. This simply implies that the demand of real money balances is a function of the contemporaneous values of output and the short-term interest rate.

As a third alternative, I estimate the impulse-response functions by imposing a Choleski identification scheme on the matrix B of contemporaneous coefficients. The Choleski scheme is equivalent to imposing a recursive structure on the underlying VAR model, and results a lower triangular B matrix. Compared to the baseline model, the Choleski scheme differs in the specification of the monetary policy equation and the money market equilibrium equation. The baseline model assumes that only the nominal exchange rate and the monetary aggregate (and the consumer price index in the Czech Republic and Hungary) contemporaneously affect the interest setting behavior of the Central Bank (cfr. equation 3.4). Here, the Central Banks' monetary policy actions are contemporaneously influenced by the Euro Area interest rate, the exchange rate, output and the price level. Furthermore, the money market equilibrium equation, which I defined in the baseline specification as a standard LM equation, is now poorly identified in that it includes the contemporaneous values of the Euro Area interest rate and the exchange rate. Finally, I estimate a second Choleski decomposition changing the ordering of the variables of the VAR. Specifically, the ordering is now the same as in alternative 2, with the exchange rate in the sixth row.

Figures 3.5 and 3.6 report the estimated dynamic responses of a one standard deviation shock to the domestic and Euro Area interest rates on stock prices for the four alternatives respectively. As it is noticeable by comparing Figures 3.1, 3.2, 3.5 and 3.6 the responses of the stock price index to an exogenous shock to the Euro Area interest rate are robust through all specifications, both in terms of magnitude and significance. The estimated response is negative in all countries: while the negative response is negative and significant in the short-run in Slovenia, the negative effect of an unexpected foreign interest rate shock is significant in the medium or long-run in the rest of the countries. Concerning the responses to an unexpected, contractionary domestic monetary policy shock, some differences arise. While the estimated impulse-responses for the Czech Republic, Poland and Slovenia are qualitatively and quantitatively consistent throughout model specifications, it is not so in the case of Hungary. In the first alternative specification, the estimated response is similar to the baseline, only surrounded by somewhat wider confidence bands which lead to a non statistically significant impact effect of the monetary policy shock on the stock price index. Nevertheless, despite the broadening of the confidence intervals, the negative response is still significant in the short and medium run. This does not hold in specifications 2, 3 and 4: the estimated responses are much less pronounced and are not statistically significant. Only in the last two specifications, the impact effect is significantly negative.

Figure 3.5: Responses of the stock price index to a +1 standard deviation innovation in the domestic and Euro Area monetary policy (±2 standard errors): Alternative 1 and 2

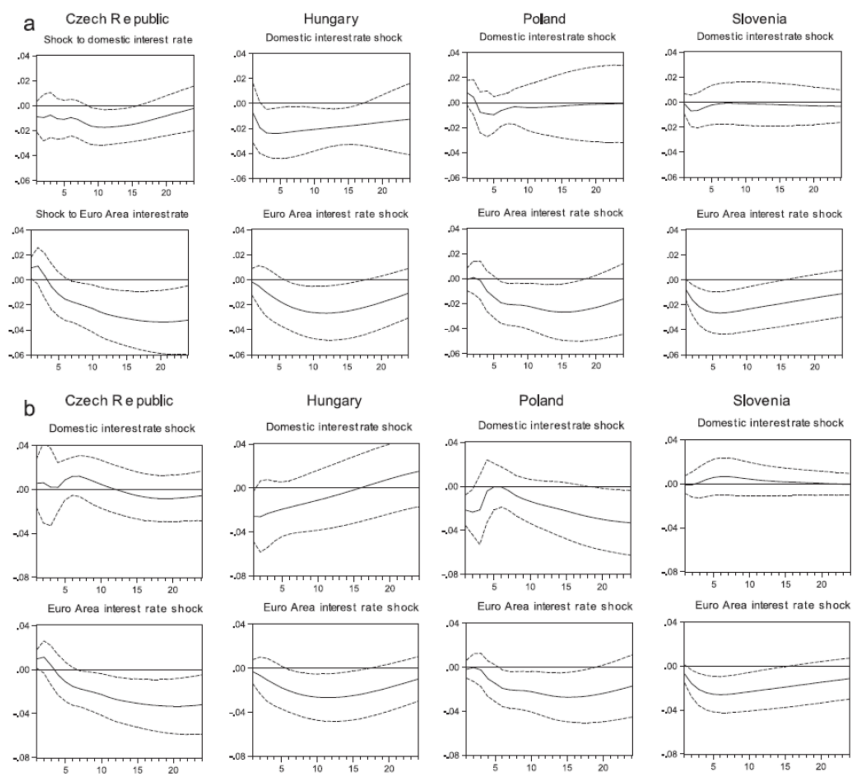
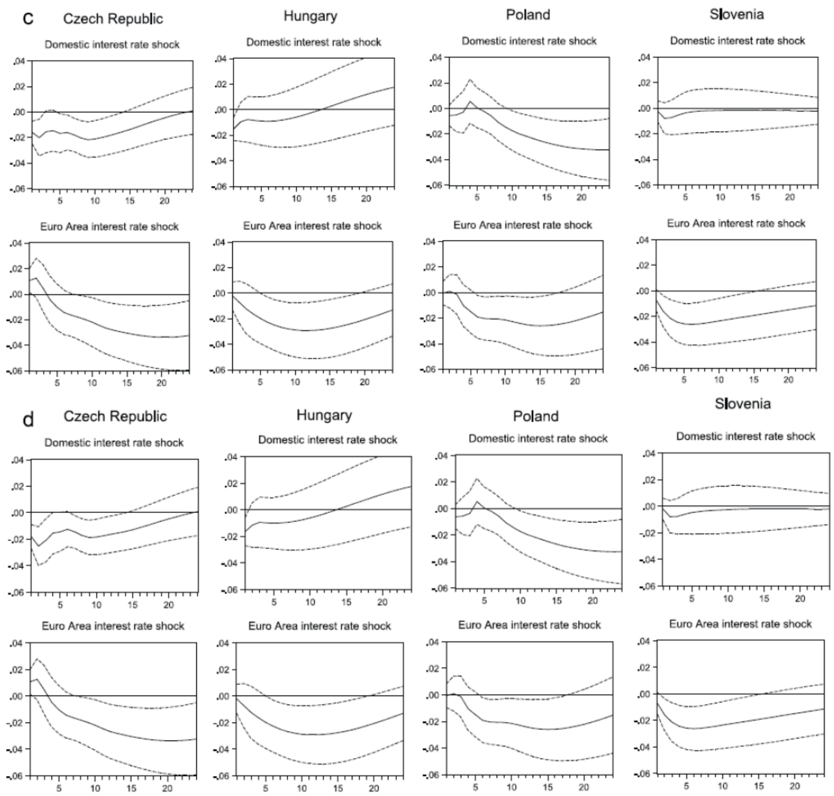


Figure 3.6: Responses of the stock price index to a +1 standard deviation innovation in the domestic and Euro Area monetary policy ($\pm$ 2 standard errors): Alternative 3 and 4



The heterogeneity of impulse-responses across model specifications in the Hungarian case might stem from the failure of the proposed schemes to identify monetary policy shocks. As reported by Vonnak (2005) and Vonnak (2008) identification of the effects of monetary policy shocks in Hungary may be particularly challenging for two reasons. First, because of the predominance, in the period 1995-2004, of supply side shocks, rather than demand shocks, in driving macroeconomic fluctuations. Secondly, because of the potential importance of risk premia in driving interest rate and exchange rate movements. In fact, given the high degree of openness of Hungarian capital markets and the predominance of foreign investors (cfr. Arvai (2005)), interest rates and exchange rates might be strongly influenced by risk perceptions of international investors and behave less in accordance to the central bank's attempt to reach its targets.

Overall, alternative 2 seems the one generating the largest differences from the baseline and from the rest of the alternative specifications. In particular, the estimated impulse-responses to a contractionary monetary policy shock lose their significance, while conserving the same qualitative features. Nevertheless, the key features of this specification (i.e. the order of the variables and the specification of the exchange rate equation) figure also in alternative 4, which provides results very consistent with the baseline. Overall, the set of robustness checks lead us to consider our results stable across different model specifications for the Czech Republic, Poland and Slovenia.

Compared to the findings of previous studies on the effect of monetary policy on stock prices in developed countries of Western Europe and North America, our results for the small open economies of Central Europe offer a different picture. Estimated impulse responses to a contractionary, domestic monetary policy shock in advanced economies reveal a significant inverse relationship between domestic interest rate and stock price movements. Studies focusing on the United States, a large and close economy, find that stock prices decrease significantly and persistently after an increase in the FED funds rate (see Thorbecke (1997), Rapach (2001), Neri (2004)). Evidence on Western European countries and Canada is largely similar. Neri (2004) finds a significant decrease in stock prices after a contractionary monetary policy shock in Germany, Italy, Spain and the United Kingdom. Only in the case of France the stock market does not seem to react to monetary policy shocks. Li, Iscan and Xu (2010) compare impulse responses for the United States and Canada, a small open economy heavily dependent on the United States, and find that the response of Canadian stock prices to domestic monetary policy are much more muted and less persistent. In contrast, I do not find a significant effect of monetary policy shocks on the stock markets of the formerly transition economies of Central Europe. While the estimated impact effect is negative in all countries, it is not statistically significant. This finding might be explained mainly by the large presence of Western European investors on the stock market, for whom the ECB interest rate is the relevant discount rate. However, I do find a statistically significant negative relationship between the Euro Area interest rate and stock prices in the new EU member states. This differs from the result by Li, Iscan and Xu (2011) according to which Canadian stock prices increase after an increase in the FED interest rate. The decline in Central European stock prices in response to a hike in the ECB interest rate may have two explanations. The first relates to the large capital inflows received by the region since the beginning of the transition process, both in form of FDI, portfolio flows and bank loans. For firms relying heavily on foreign currency loans, an increase in the Euro Area interest rate represents an increase in their production costs, which in turn reduces expected future cash flow and hence the value of the firm on the stock market. The second reason relates to the increased stock market co-movement between Western and Eastern European countries and spillovers between markets. As noted above, Western European stock markets have been found sensitive to the ECB's monetary policy, and a contractionary monetary policy action is associated with a decrease in stock prices. Given the increasing degree of integration between European stock markets (cfr. Christensen and Ranaldo (2009) and Savva and Aslanidis (2009)), spillovers may occur and depress Eastern European stock markets[45]. The analysis of the different channels of transmission of foreign monetary policy on stock prices will be the subject of future research.

[45] For example, Égert and Kočenda (2007) find that returns on stock markets in Western Europe, particularly German and French stock returns, have a significantly positive impact on stock markets in Central Europe. Furthermore, they find evidence of volatility spillovers between Western and Eastern European stock markets

3.4 Conclusion

In this paper, I estimate four structural VAR models with short-run restrictions for the Czech Republic, Hungary, Poland and Slovenia. The models represent a small-scale, small open economy model with stock prices in order to examine the interplay between financial integration, domestic monetary policy and stock prices. Three conclusions stem from our analysis.

First, I do not find robust evidence of a significant effect of domestic monetary policy on stock prices. Second, Euro Area monetary policy significantly affects stock prices in the NMS, and the effect is negative. Moreover, in all countries except Slovenia (where also the impact effect is significantly negative), the response of the stock price index seems to be transmitted to stock prices with a lag. These results suggest that in small open economies characterized by a high degree of openness to international financial markets, foreign monetary policy has a stronger effect on stock markets than domestic monetary policy. In particular, in the NMS firms rely heavily on foreign borrowing, originating mainly in Euro Area countries, to finance new investments. Hence, increases in the foreign interest rate represent an increase in their production costs, which in turn reduce expected future cash flow and stock prices. In addition, in emerging economies capital inflows amount to a large share of GDP, making them more sensitive to developments in foreign financial markets. Furthermore, in the NMS the proportion of wealth allocated to equity by domestic investors is still limited. As such, being the ECB rate the reference discount rate for Euro Area investors, stock prices are sensitive to it.

Third, the analysis of variance revealed that overall external shocks account for the bulk of variation in the stock price index in the considered countries. While exchange rate shocks are dominant in Hungary and Poland in the short-run, shocks to the Euro Area interest rate are the main determinants in the medium to long-run in Poland, in the long-run in Hungary and during the whole time horizon in Slovenia.

Hence, stock prices in the new EU member states seem to be driven by shocks related to external trade and finance. These findings have important implications for domestic policy decisions, as financial integration made local stock markets more sensitive to external shocks.

The presented analysis sheds a first light on an issue scarcely investigated before. Nevertheless, it omits important aspects worth exploring in future work. First of all, this study does not explore the channels through which Euro Area monetary policy shocks are transmitted to the NMS' stock markets. Given the increased co-movement between stock markets in the Euro Area and the NMS, the significant reaction of NMS' stock markets to Euro Area monetary policy shocks could result from spillovers between stock markets. Modeling explicitly financial linkages between the Euro Area and the NMS by means of a Global VAR model in the spirit of Dees et al (2007) will be the subject of future research. Moreover, our results could be enriched by exploring the time constancy of the estimated responses of the stock price index in the NMS. In particular, a time-varying coefficients model would allow to investigate whether such responses changed with the increase in financial integration.

3.A Appendix

Table 3.2: Phillips-Perron Unit Roots Tests

	Czech Republic		Hungary	
	Specif.	PP	Specif.	PP
$EAint$	I	-3.523 (0.626)	I	-3.523 (0.626)
ip	I,T	-1.860 (0.6750)	I	-1.835 (0.3635)
cpi	I,T	-3.481 (0,0410)*	I,T	-4.243 (0.0038)*
er	I,T	-2.739 (0.2203)	I	-4.262 (0.0005)*
i	I	-5.468 (0.0000)*	I	-3.623 (0,0053)*
m	I,T	-3,680 (0,0237)*	I,T	-1.409 (0.8582)
s	I	-0.892 (0.790)	I,T	-2.562 (0.2975)
	Poland		Slovenia	
$EAint$	I	-3.523 (0.626)	I	-3.523 (0.626)
ip	I,T	-5.217 (0.0001)*	I,T	-4.933 (0.0003)*
cpi	I,T	-4.176 (0.0049)*	I	-2.806 (0.0575)*
er	I	-2.387 (0.1453)	I	-2.126 (0.2344)
i	I	-1.427 (0.5692)	I,T	-3.374 (0.0550)*
m	I,T	-3.800 (0.0165)*	I	-3.413 (0.0105)*
s	I	-1.482 (0.5424)	I	-0.613 (0.8681)

Note: I = Intercept, T = Trend. The correct specification has been chosen by visual inspection of the data and by consideration of statistical significance
Note: *Denotes rejection of the null hypothesis of unit root

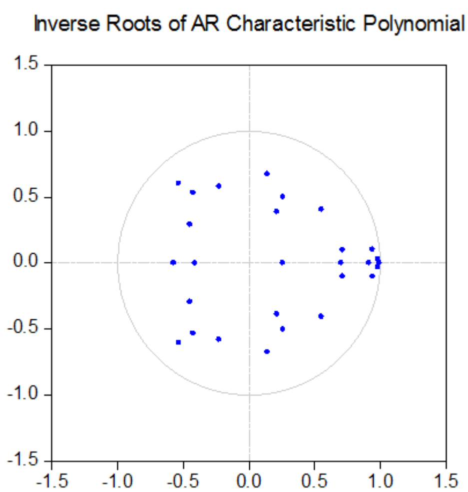
Table 3.3: Cointegration tests

	Specification	Relevant test statistic		N. cointegrating relationships
		Trace	Max. Eigenv.	
CZ	R	12.557	11.9522	2
	F	9.863	19.8935	4
HU	R	12.365	8.264	2
	F	45.411	22.358	3
PL	R	14.811	21.612	2
	F	37.470	28.762	3-4
SI	R	49.888	14.025	1
	F	29.453	14.930	3

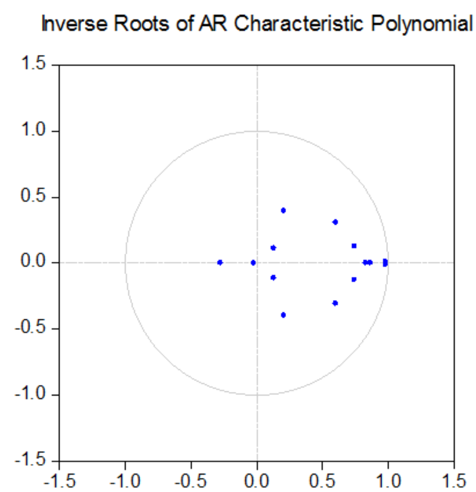
Note: R = Restriced, F= Full. The Full model includes all 7 endogenous variables. The Reduced model includes only the non-stationary variables resulting from Table A1
Note: Country names have been denoted as follows: CZ=Czech Republic, HU=Hungary, PL=Poland, SI=Slovenia
Note: The low number of detected cointegration relationships for Slovenia might be due to the fact that, given the limited sample size, the power of the tests might be lower.

Figure 3.7: Stability Check for Unrestricted VARs

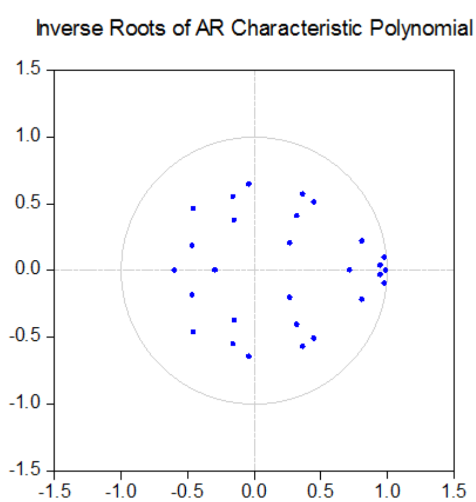
Czech Republic



Hungary



Poland



Slovenia

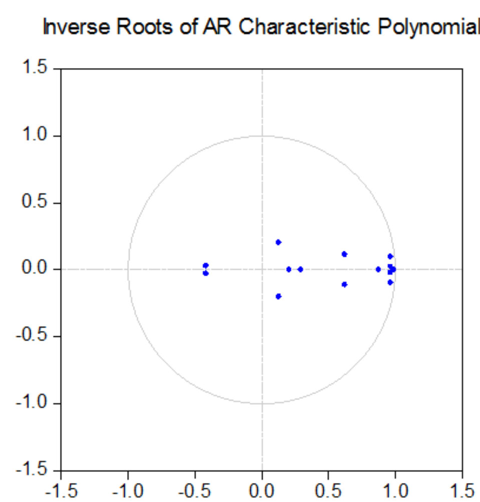


Table 3.4: Lag Length Selection

	CZ	HU	PL	SI
AIC	12	3	3	12
FPE	2	3	3	2
HQC	2	2	2	1
SC	1	1	1	1
Lag chosen	4	2	4	2

Note: Country names have been denoted as follows: CZ=Czech Republic, HU=Hungary, PL=Poland, SI=Slovenia

Table 3.5: Test for Overidentifying Restrictions

	CZ	HU	PL	SI
LR Test	2.0666*	4.9809*	2.3791*	5.4897*
p-value	0.5587	0.1732	0.6664	0.2406

*Note:** significant at the 0.95 level

Note: The models for the Czech Republic and Hungary have 3 overidentifying restrictions; those for Poland and Slovenia have 4 overidentifying restrictions

CHAPTER 4
HOUSEHOLD AND FIRM LEVERAGE, CAPITAL FLOWS AND MONETARY POLICY IN A SMALL OPEN ECONOMY

For the purpose of this chapter, three aspects of the recent financial turmoil are worth emphasizing. First, recent events demonstrate that financial imbalances with potentially systemic implications can arise even in an environment of stable inflation and economic growth. This put into question the well established objectives and instruments of monetary policy in tranquil times. On one side, the approprateness of the traditional monetary policy objectives, i.e. inflation and output stability, is being re-examined, on the grounds that they might not be necessarily conducive of financial stability. On the other hand, a debate spurred on the implementation of monetary policy, reconsidering the effectiveness of inflation targeting regimes whereby central banks set the policy rate reacting to inflation and a measure of economic activity. Hence, the dispute on monetary policy conduct in the aftermath of the crisis evolves around two main questions. Should central banks be concerned about financial, in addition to macroeconomic, stability? And, if so, should central banks react to indicators of financial overheating when setting the monetary policy rate? Secondly, the crisis highlighted the importance of developments in the real estate market, involving credit to households and real estate price dynamics. A third lesson relates to the amplification of downturns due to imbalances related to the dynamics of credit and leverage built-up in good times. Understanding the interaction between credit flows, leverage and monetary policy is essential for a thorough assessment of the adequate monetary policy responses to be implemented to prevent excess vulnerabilities to materialize. This essay presents a framework to analyze the two issues relevant to the current monetary policy debate in a small open economy reflecting the characteristics of many emerging European economies in the run-up to the crisis.

The model economy is populated by six agents: households, entrepreneurs, firms, capital and housing producers, and the central bank. The model features financial frictions affecting the credit relationships of both households and firms in a New Keynesian small open economy model. In particular, credit frictions are modeled following Bernanke, Gertler and Gilchrist (1999), postulating the existence of an asymmetric information problem between borrowers and lenders implying costly state verification and generating an external finance premium directly linked to borrowers' leverage. Hence, in such a context, fluctuations in asset prices affect agents' ability to borrow and contribute to their overall leverage position. Furthermore, debt is denominated in foreign currency, therefore, exchange rate movements impact on borrowers' balance sheets.

The capital inflow shock is embedded into the asymmetric information set-up following Curdia (2007, 2008). In particular, it is assumed that foreign lenders have a distorted perception of borrowers' creditworthiness. In good times, lenders become optimistic about borrowers' productivity, leading them to enforce looser credit conditions to borrowers. Lower lending rates strengthen the balance sheet position of borrowers, encouraging them to undertake more projects, thereby increasing investment and asset prices and leading to a self-fulfilling virtuous cycle of economic expansion. This mechanism, albeit stylized, is able to replicate the credit and investment increases observed in the Central and Eastern European economies during capital inflow surges. In order to introduce the capital inflow shock consistently in the two sectors (real estate and capital investment), I assume the existence of capital and housing producers that buy final goods and convert them in new housing and capital stock. In the production sector, entrepreneurs invest in new capital goods using their own net worth and borrowing from foreign financial intermediaries, who face a costly state verification problem and charge an external finance premium dependent on leverage. They rent their capital to production firms who produce for the domestic and foreign market, and are subject to staggered price setting. In order to keep consistency and tractability, the housing market is modeled following Aoki, Proudman and Vlieghe (2004). In particular, it is assumed that households are composed of two behavioral types: homeowners and consumers. Homeowners are analogous to entrepreneurs: they use own net worth and borrowed funds to finance housing investment. The credit relationship is characterized by the same asymmetric information problem faced by entrepreneurs. Homeowners then rent the housing stock to consumers, which also consume domestic and imported goods and supply labor to domestic firms. In order to capture wealth effects in the household sector deriving from real estate price fluctuations, it is assumed that, at the end of each period, homeowners perform a transfer to consumers within the household. This simple modeling framework captures the fact that households can use their housing equity to finance consumption.[46] More specifically, the transfer is related to the household's leverage: when equity rises, the household can either accumulate the extra net worth thereby easing her credit condition in the following period, or use it to increase current consumption by increasing the transfer. Finally, the central bank sets the nominal interest rate according to a policy rule.

4.1 The model

4.1.1 Households

Households are composed of two behavioral types, homeowners and consumers. While the former undertake housing investment and own the housing stock, the latter rent housing services and consume consumption goods. Consumers are further divided in two types. A fraction n of consumers is Ricardian (R), has access to do-

[46] In other terms, households are able to borrow against the value of their home to finance consumption, a practice often named mortgage equity withdrawal.

mestic and foreign assets and is able to smooth consumption over time. The remaining $(1-n)$ consumers are non-Ricardian (NR), and consume their current income in each period.[47] Both types of consumers supply differentiated labor services to unions, which act as wage setters in monopolistically competitive markets. Income of NR consumers is then made up of wage income plus a transfer received from homeowners. Finally, as the economy is open, the consumption bundle is composed of domestic and imported goods.

Consumers

The utility function common to all consumers is expressed in terms of consumption (C_t) and labor services (N_t) :

$$U\left(C_{t,}N_t\right) = \frac{\left(C_t - \tau C_{t-1}\right)^{1-\sigma}}{1-\sigma} - \chi_N \frac{\left(N_t\right)^{1+\varphi}}{1+\varphi}$$

Where τ is the habit formation parameter, σ and φ are respectively the elasticities of intertemporal substitution and of labor supply, and χ_N is a scaling parameter for the disutility of working hours. The consumption bundle C_t is composed of consumption goods c_t and housing services h_t:

$$C_t = \left[\gamma_c^{\frac{1}{\varsigma}} \left(c_t\right)^{\frac{\varsigma-1}{\varsigma}} + \left(1-\gamma_c\right)^{\frac{1}{\varsigma}} \left(h_t\right)^{\frac{\varsigma-1}{\varsigma}}\right]^{\frac{\varsigma}{\varsigma-1}}$$

Where ς is the elasticity of substitution between consumption and housing services, and γ_c is the weight of goods consumption in the overall basket. Furthermore, consumers allocate consumption between domestically produced (c_t^H) and imported

47 In the context of this study, this modeling choice is dictated by the necessity to incorporate a transfer from homeowners to consumers, in order to obtain wealth effects from investment. In general, the introduction of Non-Ricardian households in DSGE models is motivated by the empirical evidence suggesting a high dependence of consumption from current income, which cannot be obtained when households satisfy the permanent income hypothesis (Gali', Lopez-Salido and Vallés (2007). Campbell and Mankiw (1989) and Mankiw (2000) provide empirical evidence on the relationship between consumption and income in advanced economies).

(c_t^F) goods, so that $c_t = \left[\gamma_h^{\frac{1}{\eta}} \left(c_t^H\right)^{\frac{\eta-1}{\eta}} + (1-\gamma_h)^{\frac{1}{\eta}} \left(c_t^F\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$, where η represents the elasticity of substitution between domestic and foreign goods. It follows that the consumer price index P_t is defined as $P_t = \left[\gamma_h \left(P_t^H\right)^{1-\eta} + (1-\gamma_h) \left(P_t^F\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$, where P_t^H and P_t^F are respectively the price of domestically produced and imported goods. As all consumers share the same preferences and face the same prices, intratemporal optimization results in the following demand schedules for consumption, housing services, domestic and imported goods:

$$\frac{c_t}{h_t} = \frac{\gamma_c}{1-\gamma_c}\left(\frac{1}{p_t^h}\right)^{-\varsigma} \tag{4.1}$$
$$c_t^H = \gamma_h \left(p_t^H\right)^{-\phi} c_t \tag{4.2}$$
$$c_t^F = (1-\gamma_h) \left(p_t^F\right)^{-\phi} c_t \tag{4.3}$$

Furthermore, I assume that housing services are a constant fraction s of the housing stock:

$$h_t = sH_t \tag{4.4}$$

While intratemporal choices are analogous for the two types of consumers, only Ricardian consumers face an intertemporal choice problem, maximizing the discounted value of lifetime utility subject to the budget constraint[48]:

$$C_t^R + \frac{R_t B_t}{P_t} + R_t^* \Psi_t \frac{S_t B_t^*}{P_t} = \frac{W_t}{P_t} N_t^R + \frac{B_{t+1}}{P_t} + \frac{S_t B_{t+1}^*}{P_t} + \Pi_t - T_t^R$$

Ricardian consumers have access to domestic (B_t) and foreign (B_t^*) borrowing. While both assets are of a risk-free nature, access to the international financial market is subject to small transaction costs Ψ_t. Hence, while the domestic asset carries the

48 Variables pertaining to Ricardian (Non-Ricardian) consumers are denoted with the superscript R, (NR).

gross domestic risk-free interest rate R_t, the cost of foreign borrowing is $R_t^*\Psi_t$, where the portfolio adjustment cost Ψ_t is a function of the aggregate foreign debt of the small open economy $(B_{t+1}^* + L_{t+1}^E + L_{t+1}^H)$[49]:

$$\Psi_t = \exp\left[-\phi_B\left(\frac{S_t(B_{t+1}^* + L_{t+1}^E + L_{t+1}^H)}{Y_t} - \frac{S(B^* + L^E + L^H)}{Y}\right)\right] \tag{4.5}$$

Furthermore, Ricardian households receive profits from the ownership of firms (Π_t) and pay lump-sum taxes to the government (T_t^R). Denoting with λ_t the lagrange multiplier on the budget constraint, the following conditions hold:

$$\lambda_t = \left(C_t^R - \tau C_{t-1}^R\right)^{-\sigma} \tag{4.6}$$

$$\lambda_t = \beta E_t\left\{\lambda_{t+1}\frac{R_t}{\pi_{t+1}}\right\} \tag{4.7}$$

$$\lambda_t = \beta E_t\left\{\lambda_{t+1}\frac{S_{t+1}}{S_t}\Psi_t\frac{R_t^*}{\pi_{t+1}}\right\} \tag{4.8}$$

Non-Ricardian consumers are of measure $(1-n)$ and are assumed to fully consume their income in every period. Consumption of NR households is then determined by their wage income, dividends from homeowners[50] (D_t) and lump-sum taxes (T_t^{NR}), as follows:

$$C_t^R = \frac{W_t}{P_t}N_t^{NR} + D_t - T_t^{NR} \tag{4.9}$$

Aggregating over R and NR consumers, total consumtpion results in: $C_t = nC_t^R + (1-n)C_t^{NR}$.

[49] Variables without time subscript denote steady state values. This specification of the portfolio adjustment cost implies that the cost of foreign borrowing is higher the higher the net indebtness of the economy. While the coefficient ϕ_B is so small that it does not affect the dynamics of the model, introducing a portfolio adjustment cost in small open economy models guarantees the existence of a well defined steady state and delivers a stationary path for net foreign assets and consumption (Schmitt-Grohé and Uribe (2003)).

[50] Details on the specification of the transfer follow in section 3.1.2.

The wage setting process and the consequent labor supply decision are governed by unions. Both R and NR consumers supply differentiated labor services to a continuum of monopolistically competitive unions[51], which act as wage setters taking the aggregate wage W_t and the aggregate labor demand N_t^d as given. Unions pool the wage income of all consumers and then distribute the aggregate wage income in equal proportion among the latter. The union then takes W_t and N_t^d as given and sets the optimal wage $\tilde{W}_t(i)$ to equate the union's expected average marginal return and the marginal cost of supplying labor [52]. However, in doing so the union faces nominal rigidities in the Calvo fashion. Specifically, in each period the wage can be optimized only in a fraction $(1-\theta^w)$ of labor markets. In the remaining fraction θ^w the real wage is indexed to past inflation resulting in the following law of motion of the aggregate wage (where ε_w represents the elasticity of substitution between different labor types):

$$W_t = \left[(1-\theta^w)\,\tilde{W}_t^{1-\varepsilon_w} + \theta^w\left(W_{t-1}(i)\pi_{t-1}\right)^{1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}} \tag{4.13}$$

Given the assumptions concerning the population of consumers, aggregate labor supply is given by $N_t = nN_t^R + (1-n)N_t^{NR}$.

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[51] See Conen and Straub (2004) for this specification in the context of Ricardian and Non-Ricardian consumers.

[52] The first order conditions can be formulated in the following recursive fashion, where $\Lambda_{t+k} = (C_{t+k})^{-\sigma}$ is the marginal utility of consumption of all consumers:

$$\begin{aligned} K_t^w &= \left(\frac{\varepsilon_w-1}{\varepsilon_w}\right)\tilde{W}_t\Lambda_t N_t\left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} + \beta\theta^w\left(\frac{\pi_{t+1}}{\pi_t}\frac{\tilde{W}_{t+1}}{\tilde{W}_t}\right)^{\varepsilon_w-1} K_{t+1}^w & (4.10)\\ F_t^w &= \chi_H\left(N_t^d\right)^{\varphi}\left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} N_t + \beta\theta^w\left(\frac{\pi_{t+1}}{\pi_t}\frac{\tilde{W}_{t+1}}{\tilde{W}_t}\right)^{\varepsilon_w} F_{t+1}^w & (4.11)\\ K_t^w &= F_t^w & (4.12)\end{aligned}$$

However, given the hypothesis that unions pool wage incomes of R and NR consumers, labor market equilibrium requires:

$$N_t = N_t^R = N_t^{NR} \tag{4.14}$$

In order to ensure that the wage rate is the same for the two consumer types, hours worked must be equalized.[53]

Homeowners

Housing investment decisions are made by homeowners, who act like entrepreneurs in the model. Homeowners are risk neutral, they purchase housing from housing producers, transform it into homogeneous rentable units and rent them to consumers. At the end of period t the $i-$th homeowner has available net worth equal to $NW_{t+1}^H(i)$. At time t she purchases unfinished housing ($H_{t+1}(i)$) from housing producers at a unit price $Q_{h,t}$ and finances the part of investment in excess of her net worth by stipulating foreign currency loans $L_{t+1}^H(i)$.[54] In the next period, she will use unfinished housing to produce rentable units, which will be rented to consumers at a rental price $P_{h,t+1}$. Homeowners borrow from a competitive foreign financial intermediary whose relevant opportunity cost is the gross risk-free rate prevailing in the foreign country, R_{t+1}^*. The typical homeowner faces the following budget constraint, expressed in domestic currency:

$$NW_{t+1}^H(i) = Q_{h,t}H_{t+1}(i) - S_t L_{t+1}^H(i)$$

[53] This also arises as a result of the fact that firms allocate their labor demand uniformly across labor varieties, independently of their consumer type (R or NR).

[54] Note that loans are stipulated in period t but will be repayed at $t+1$, hence the choice of subscript. Similarly, housing purchased at time t will be used in the next period, hence the time subscript.

The expected gross return of a unit of housing investment is composed of the return from renting houses to consumers (i.e. the rental price of houses, $P_{h,t}$) and the value of the undepreciated housing stock, adjusted for the change in price:

$$E_t\left\{R^H_{t+1}\right\} = E_t\left\{\frac{sP^h_{t+1} + (1-\delta_h)Q_{h,t+1}}{Q_{h,t}}\right\} \tag{4.15}$$

Where δ_h is the depreciation rate of the housing stock.

Each homeowner has access to a stochastic technology that transforms $H_{t+1}(i)$ units of unfinished housing into $H_{t+1}(i) = \omega^H_{t+1}(i)H_{t+1}(i)$ rentable units. The idiosyncratic productivity shock $\omega^H_{t+1}(i)$ is iid across homeowners and time and it is assumed to follow a lognormal distribution with density $f(\omega^H)$ and $E\left\{\omega^H\right\} = 1$[55]. The realization of productivity is freely observed by homeowners, but lenders can only observe it by incurring a monitoring cost proportional to the gross payoff to the homeowner's project ($\mu^H(\omega^H_{t+1}(i)R^H_{t+1}Q_{h,t}H_{t+1}(i))$): this asymmetric information is at the core of the external finance premium. Furthermore, following Curdia (2007), I assume that lenders have a distorted perception of the productivity parameter. In particular, the lenders' perception of productivity is $\omega^{H*}_{t+1} = \omega^H_{t+1}\upsilon^H_t$ where $\upsilon^H_t \in [0,1]$ is the misperception factor which evolves according to $\ln(\upsilon^H_t) = \rho_\upsilon \ln(\upsilon^H_{t-1}) + \xi^H_\upsilon$. ξ^H_υ is a shock to lenders perceptions of homeowners' productivity and it is the origin of capital inflows in the model. When υ^H_t increases, lenders perceive homeowners' to be more productive or, in other words, they perceive their default probability to be lower. Hence, they will charge a lower premium, allowing borrowers to expand their balance sheet. The optimal credit contract between financial intermediaries and homeowners specifies a fixed payment (equal to $R^H_{L,t+1}$) to the lender whenever the return to to investment is above the cutoff value ($\bar{\omega}^H_{t+1}(i)$) that determines default. Otherwise, the homeowner defaults on her debt and the lender seizes the remaining

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55 In particular, $\omega^H \sim \log N\left(-\frac{\sigma^2_H}{2}, \sigma^2_H\right)$, where σ^2_H represents the variance of the underlying Normal distribution.

value of the project, after paying the monitoring cost. The non-default cutoff value is the productivity level $\bar{\omega}^H_{t+1}(i)$ equating the homeowner's receipts with the repayment of the loan:

$$\bar{\omega}^H_{t+1}(i)\frac{Q_{h,t}H_{t+1}(i)R^H_{t+1}}{S_{t+1}} = R^H_{L,t+1}\frac{(Q_{h,t}H_{t+1}(i) - NW^H_{t+1}(i))}{S_t} \tag{4.16}$$

Taking as given $Q_{h,t}$, R^H_{t+1} and net worth $NW^H_{t+1}(i)$, the optimal contract is fully specified in terms of the threshold productivity level $\bar{\omega}^H_{t+1}(i)$ and demand for initial investment $H_{t+1}(i)$.[56] The optimal contract maximizes the expected payoff of the borrower subject to the lender's participation constraint. The expected payoff of the homeowner is:

$$E_t\left[\left(Q_{ht}H^H_{t+1}(i)R^H_{t+1}\right)\left(A^H(\bar{\omega}^H_{t+1}(i))\right)\right] = \tag{17}$$
$$E_t\left[\left(\int_{\bar{\omega}^H_{t+1}(i)}^{\infty}\omega^H_{t+1}(i)f(\omega^H)d\omega^H\right)\left(Q_{h,t}H_{t+1}(i)R^H_{t+1}\right) - \left(\int_{\bar{\omega}^H_{t=1}(i)}^{\infty}f(\omega^H)d\omega^H\right)R^H_{L,t+1}L^H_{t+1}(i)\right]$$

Where $A^H(\bar{\omega}^H_{t+1}(i))$ represents the fraction of the expected payoff captured by homeowners. As foreign lenders are risk neutral, they engage in the contract if it guarantees an expected payoff at least equal to what they would obtain by investing in the risk-free asset. The following participation constraint has to hold:

$$\frac{R^H_{t+1}Q_{h,t}H_{t+1}(i)}{S_{t+1}}\left[B^H\left(\bar{\omega}^H_{t+1}, \upsilon^H_t\right)\right] = R^*_t L^H_{t+1}(i) \tag{4.18}$$

Where $R^H_{t+1}Q_{h,t}H_{t+1}(i)\left[B^H\left(\bar{\omega}^H_{t+1}, \upsilon^H_t\right)\right] =$

[56] Recall that P^h_{t+1} is a market price, and as such it will be determined by the equilibrium between demand and supply of rentable houses.

$\left[\begin{array}{c} \left(\int_{\bar{\omega}^H_{t+1}(i)}^{\infty} f(\omega^{H*})d\omega^{H*}\right) R^H_{L,t+1} L^H_{t+1}(i) + \\ \left(\int_0^{\bar{\omega}^H_{t+1}(i)} \omega^{H*}_{t+1} f(\omega^{H*})d\omega^{H*}\right) (1-\mu^H) Q_{h,t} H_{t+1}(i) R^H_{t+1} \end{array} \right]$ is the lender's expected payoff and $B^H\left(\bar{\omega}^H_{t+1}, \upsilon^H_t\right)$ is the fraction of homeowner's payoff captured by the lender (recall the definition $\omega^{H*}_t = \omega^H_t \upsilon^H_t$), net of monitoring cost.

As ω^H_{t+1} is iid and independent of all other shocks in the model, homeowners are identical $ex-ante$, face the same contract and will be charged the same lending rate. The first order conditions of the optimal credit contract are obtaining maximizing (4.17) subject to (4.18) [57]:

$$E_t\left(R^h_{t+1}\right) = R^*_{t+1}\left[\frac{A'^H(\bar{\omega}^H_{t+1})}{B^H\left(\bar{\omega}^H_{t+1}, \upsilon^H_t\right) A'^H(\bar{\omega}^H_{t+1}) - B'^H\left(\bar{\omega}^H_{t+1}, \upsilon^H_t\right) A^H(\bar{\omega}^H_{t+1})} E_t\left\{\frac{S_{t+1}}{S_t}\right\}\right] \tag{4.19}$$

$$\frac{Q_{h,t} H_{t+1}}{NW^H_{t+1}} = \frac{1}{\left(1 - \frac{S_t}{S_{t+1}} \frac{R^H_{t+1}}{R^*_{t+1}} B^H\left(\bar{\omega}^H_{t+1}, \upsilon^H_t\right)\right)} \tag{4.20}$$

Equation (4.20) implies that the demand for unfinished housing by homeowners is positively related to the rental price of housing P^h_{t+1}, which enters R^h_{t+1}, and inversely related to the price of housing good, $Q_{h,t}$. Equation (4.19) is the basis of the financial accelerator in the model. It links the cost of external finance to homeowners' financial position and, hence, to their demand for housing good. In fact, risk premia are a positive function of $\bar{\omega}^H_{t+1}$ which is, in turn, a positive function of the homeowner's leverage. Hence, lower leverage implies lower probability of default and hence a lower risk premium. Furthermore, as borrowing is denominated in foreign currency, exchange rate movements also affect the risk premium: a domestic currency appreciation (decrease in S_{t+1}) lowers the risk premium both directly and indirectly by decreasing the value of outstanding debt and thereby lowering leverage.

The description of homeowners' behavior is by the description of the evolution of their net worth. A the end of each period, non-defaulting homeowners keep their

[57] Here, $A'(\omega) = \frac{\partial A(\omega)}{\partial \omega}$.

payoff net of loan repayment, which is going to increment their stock of equity. Furthermore, homeowners perform a transfer (D_t) to consumers within the household[58], which positively depends on the inverse leverage ratio ($\frac{NW^H_{t+1}}{Q_{h,t}H_{t+1}}$) and is given by:

$$D_t = \chi_D \left(\frac{NW^H_{t+1}}{Q_{h,t}H_{t+1}} \right) \tag{4.21}$$

This simple rule captures the concept that, following a rise in real estate prices, homeowners are faced with two choices. They can either keep the transfer constant and accumulate more net worth (thereby increasing their equity and enjoying looser credit conditions in the future), or they can increase the transfer to consumers leading to an increase of current household consumption. Hence, this is a simple way to generate wealth effects of real estate prices, and a positive correlation between housing prices and consumption observed in the data (see Iacoviello (2010)). Furthermore, homeowners are assumed to be endowed with a unit of labor, which they supply inelastically to domestic firms. The evolution of homeowners' net worth can be represented as:

$$NW^H_{t+1} = A^H(\bar{\omega}^H_t)R^H_t Q_{h,t-1}H^H_t - D_t + W^H_t N^H_t \tag{4.22}$$

4.1.2 Housing and Capital Producers

Housing and capital producers operate in a regime of perfect competition.[59] In each period, they combine investment goods ($I_{j,t}$, with price $P^I_{j,t}$, $j = k, h$) and the old undepreciated capital (housing) stock to produce new capital (housing) goods, which will be sold at the real price $Q_{k,t}$ ($Q_{h,t}$)[60]. Investment is subject to adjustment costs,

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[58] Here, the transfer is not fully microfounded. Its specification follows Aoki, Proudman and Vlieghe (2004).

[59] Here, I denote with subscript k (h) variables pertaining to capital (housing) producers.

[60] The investment bundle for both producers has a similar composition of the consumption bundle, cfr equation ().

represented by the function $\Phi_{j,t} = \frac{\kappa_j}{2}\left(\frac{I_{j,t}}{I_{j,t-1}} - 1\right)^2$ (Smets and Wouters (2003)). Capital producers choose the optimal amount of investment so as to maximize the profits, leading to the following first order condition:

$$\begin{aligned} 1 &= q_{k,t}\left[1 - \frac{\kappa_t}{2}\left(\frac{I_{k,t}}{I_{k,t-1}} - 1\right)^2 - \kappa_t\left(\frac{I_{k,t}}{I_{k,t-1}} - 1\right)\left(\frac{I_{k,t}}{I_{k,t-1}}\right)\right] \\ &\quad + \beta E_t\left\{\frac{\lambda_{t+1}}{\lambda_t} q_{k,t+1}\left[\kappa\left(\frac{I_{k,t+1}}{I_{k,t}} - 1\right)\left(\frac{I_{k,t+1}}{I_{k,t}}\right)^2\right]\right\} \end{aligned} \tag{4.23}$$

Where $q_{k,t}$ is the real price of the capital stock defined as $\frac{Q_{k,t}}{P_t}$. The law of motion of the economy wide capital stock is:

$$K_{t+1} = \left[1 - \frac{\kappa_t}{2}\left(\frac{I_{k,t}}{I_{k,t-1}} - 1\right)^2\right] I_{k,t} + (1 - \delta_k)\, K_t \tag{4.24}$$

Analogous expressions hold for housing producers, with the subscript k replaced by h.

4.1.3 Entrepreneurs

The behavior of entrepreneurs closely mirrors that of homeowners. Entrepreneurs engage in capital investment, and in each period they purchase capital from capital producers ($Q_{k,t}K_{t+1}$) using their net worth (NW^E_{t+1}) and borrowing from foreign financial intermediaries (L^E_{t+1}) with a lending rate $R^E_{L,t+1}$. The return from capital investment, R^E_{t+1}, is given by the return from renting capital to firms (r^K_t) and the capital gain:

$$R^E_{t+1} = \frac{r^K_{t+1} + (1 - \delta_k)\, Q_{k,t+1}}{Q_{k,t}} \tag{4.25}$$

Furthermore, each entrepreneur has a stochastic technology

$\omega^E_{t+1}(i) \sim \log N(-\frac{\sigma^2_E}{2}, \sigma^2_E)$, the realization of which determines the profitability of their investment and, then, their default probability. The threshold productivity level that discriminates between defaulting and non-defaulting entrepreneurs is given by:

$$\bar{\omega}^{E}_{t+1}(i)\frac{Q_{k,t}K_{t+1}(i)R^{E}_{t+1}}{S_{t+1}} = R^{E}_{L,t+1}L^{E}_{t+1}(i) = R^{E}_{L,t+1}\frac{(Q_{k,t}K_{t+1}(i) - NW^{E}_{t+1}(i))}{S_t} \tag{4.26}$$

Finally, as in the case of homeowners, lenders have a distorted perception of entrepreneurial productivity, given by $\omega^{E*}_{t+1} = \omega^{E}_{t+1}\upsilon^{E}_{t}$ where $\upsilon^{E}_{t} \in [0,1]$ is the misperception factor which evolves according to $\ln(\upsilon^{E}_{t}) = \rho_{\upsilon}\ln(\upsilon^{E}_{t-1}) + \xi^{E}_{\upsilon}$. The optimal financial contract is identical to that faced by homeowners and the first order conditions result in:

$$E_t\left(R^{E}_{t+1}\right) = R^{*}_{t+1}\left[\frac{A'^{E}(\bar{\omega}^{E}_{t+1})}{B^{E}\left(\bar{\omega}^{E}_{t+1},\upsilon^{E}_{t}\right)A'^{E}(\bar{\omega}^{E}_{t+1}) - B'^{E}\left(\bar{\omega}^{E}_{t+1},\upsilon^{E}_{t}\right)A^{E}(\bar{\omega}^{E}_{t+1})}E_t\left\{\frac{S_{t+1}}{S_t}\right\}\right] \tag{4.27}$$

$$\frac{Q_{k,t}K_{t+1}}{NW^{E}_{t+1}} = \frac{1}{\left(1 - \frac{S_{t+1}}{S_t}\frac{R^{E}_{t+1}}{R^{*}_{t+1}}B^{H}\left(\bar{\omega}^{E}_{t+1},\upsilon^{E}_{t}\right)\right)} \tag{4.28}$$

Contrary to the case of homeowners, entrepreneurs do not pay a transfer. In order to characterize the evolution of their net worth it is assumed that entrepreneurs have finite horizon: in particular, a proportion $(1-\varrho)$ of entrepreneurs die in each period but are immediately replaced by newcomers, so that the total population is constant. This is necessary to guarantee that the net worth of entrepreneurs does not grow to the point they can finance their investment using their equity only. Furthermore, entrepreneurs are endowed with a unit of labor that they supply inelastically to firms, paying a wage W^{E}_{t}. At the end of period t, entrepreneurs collect their investment payoff and honour the debt obligations contracted in the previous period. Net worth of surviving entrepreneurs is then composed of the profits from investment and wage income:

$$NW^E_{t+1} = \varrho\left[A^E(\bar{\omega}^E_t)R^E_t Q_{k,t-1}K_t\right] + W^E_t \tag{4.29}$$

Entrepreneurs exiting the market consume their remaining equity:

$$P_t C^E_t = (1-\varrho)A^E(\bar{\omega}^E_t)R^E_t Q_{k,t-1}K_{t-1} \tag{4.30}$$

Entrepreneurs consume domestic and import good in the same mix as consumers, the deman functions of which are:

$$C^E_{H,t} = \gamma_h \left(p^H_t\right)^{-\phi} C^E_t \tag{4.31}$$

$$C^E_{F,t} = (1-\gamma_h)\left(p^F_t\right)^{-\phi} C^E_t \tag{4.32}$$

4.1.4 Firms

There exist two types of firms in the economy. A continuum of intermediate producers indexed by $f \in [0,1]$ operates in a monopolistically competitive environment and produce differentiated goods employing capital and labor. Furthermore, these firms face price rigidities à la Calvo, implying staggered priced setting. Then, a set of perfectly competitive final goods producers aggregate costlessly the differentiated intermediate goods into a single final good, which is then sold to consumers (both domestically and abroad).

Final good producers

Final good producers operate in a perfectly competitive environment. They purchase intermediate goods $Y_t(f)$ and aggregate them to obtain the final good $Y_t = \left[\int_0^1 Y_t(f)^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}}$[61]. The final good is sold both domestically and abroad. In particular, the export good is produced one-for-one by a representative competitive pro-

[61] ε denotes the elasticity of substitution between varieties of domestic goods.

ducer, using the domestic final good as input. The foreign demand for the domestic good is given by:

$$X_t = \gamma^* \left(\frac{P_t^x}{P_t^*}\right)^{-\mu_x} Y_t^* \tag{4.33}$$

Where P_t^* is the foreign price index and Y_t^* is foreign output. μ_x represents the elasticity between domestically produced and imported goods in the foreign country. Finally, γ^* is the share of imports in the foreign country's consumption basket. I assume that the law of one price holds in the export market, implying that the domestic good sells for the same price on the two markets when converted to the same currency. Hence, defining the nominal exchange rate S_t as the price of the foreign currency in terms of domestic currency, the price of exports in foreign currency is $P_t^x = \frac{P_{H,t}}{S_t}$:

Intermediate goods producers

A continuum of intermediate good producers indexed by f operate under monopolistic competition and is owned by Ricardian households. Producers use capital and three types of labor inputs (N_t, N_t^E and N_t^H, supplied respectively by consumers, entrepreneurs and homeowners) to produce differentiated goods. The production function for domestic intermediate good producers is:

$$Y_t(f) = e^{A_t} K_t^{\alpha}(f)\, N_t(f)^{(1-\alpha)(1-\Omega_E-\Omega_H)}\, N_t^E(f)^{(1-\alpha)\Omega_E}\, N_t^H(f)^{(1-\alpha)\Omega_H} \tag{4.34}$$

Where α is the share of capital in production, Ω_E and Ω_H are the shares of entrepreneurial and homeowners' labor in production. Cost minimization implies the following standard factor demand functions, where $r_{k,t}$ denotes the rental rate of capital:

$$\begin{aligned} W_t &= MC_t\,(1-\alpha)\,(1-\Omega_E-\Omega_H)\,\frac{Y_t\,(f)}{N_t\,(f)} && (4.35)\\ W_t^E &= MC_t\,(1-\alpha)\,\Omega_E\,\frac{Y_t\,(f)}{N_t^E\,(f)} && (4.36)\\ W_t^H &= MC_t\,(1-\alpha)\,\Omega_F\,\frac{Y_t\,(f)}{N_t^H\,(f)} && (4.37)\\ r_t^K &= MC_t\alpha\frac{Y_t\,(f)}{K_t\,(f)} && (4.38) \end{aligned}$$

Price setting is staggered. In each period, only a fraction $(1-\theta)$ of firms are allowed to reset their price optimally. The fraction θ that is not allowed to optimize sets the price equal to that prevailing in the previous period, indexing it to past inflation at a rate γ_p and to the steady state inflation rate at rate $\left(1-\gamma_p\right)$. As all firms allowed to optimize set the same price, denoted as $\tilde{P}_{H,t}$, the domestic good price evolves as: $P_t^H = \left[\theta\left(P_{t-1}^H\left(\pi_{t-1}^H\right)^{\gamma_p}\left(\pi^H\right)^{1-\gamma_p}\right)^{1-\varepsilon} + (1-\theta)\left(\tilde{P}_t^H\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$.

Import firms

Importers operate in a monopolistically competitive environment. They purchase the foreign differentiated good at the (domestic currency) price $S_t P_t^*$, repackage it and resell it in the domestic market. Price setting is staggered à la Calvo: in each period, they can optimally reset prices with probability θ_m. This introduces imperfect exchange rate pass-through in import prices following Monacelli (2003). The price index of imported goods is given by $P_t^f = [(1-\theta_m)\,(P_{f,t}^{new})^{1-\mu_m} + \theta_m(P_{t-1}^f)^{1-\mu_m}]^{\frac{1}{1-\mu_m}}$, where μ_m is the elasticity of substitution between different varieties of import goods. Each firm in the import sector chooses the optimal price as to maximize discounted profits[62] subject to the demand constraint $Y_{t+k}^M(j) =$

[62] As import firms are owned by Ricardian consumers, $\Lambda_{t,t+k} = \frac{C_t^{R\,\sigma}}{C_{t+k}^{R\;\;\sigma}}$ is the consumers' stochastic discount factor.

$\left(\frac{P_t^f(j)}{P_{t+k}^f}\right)^{-\mu_m} Y_{t+k}^M$, where $P_t^f = \left(\int_0^1 P_t^f(j)^{1-\mu} dj\right)^{\frac{1}{1-\mu}}$ and Y_t^M denotes aggregate imports demand. In the symmetric equilibrium, all firms allowed to reset price will set it at the same level, equal to a markup over current and expected future marginal costs (which in the case of import firms are equal to $\frac{S_{t+k}P_{t+k}^*}{P_{t+k}^f}$).

4.1.5 Aggregate demand and balance of payments

Domestically produced goods are used for domestic consumption by consumers and entrepreneurs, investment by housing and capital goods producers, government expenditure (G_t), exports (X_t) and to pay monitoring costs arising from imperfect information in the credit relationships between financial intermediaries and homeowners and entrepreneurs (M_t^H and M_t^E)[63]. Hence, the national accounting identity reads:

$$Y_t = c_t^H + C_{H,t}^E + I_{k,t}^H + I_{h,t}^H + G_t + X_t + M_t^H + M_t^E \tag{4.39}$$

Imported goods are used for consumption and investment, hence total imports (Y_t^M) are defined as:

$$Y_t^M = c_t^F + C_{F,t}^E + I_{k,t}^F + I_{h,t}^F \tag{4.40}$$

Finally, the balance of payments of the small open economy is obtained by aggregating the budget constraints of consumers, homeowners and entrepreneurs, and results in the following expression:

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63 Given the distribution of ω_t^H and ω_t^E, the fraction of payoff used to monitor borrowers in the two sectors amounts to:

$$\begin{aligned} M_t^H &= \mu^H \cdot F\left(\frac{\ln\bar{\omega}_t^H - 0.5\sigma_H^2}{\sigma_H}\right) \cdot R_t^h Q_{h,t-1} H_t \\ M_t^E &= \mu^E \cdot F\left(\frac{\ln\bar{\omega}_t^E - 0.5\sigma_E^2}{\sigma_E}\right) \cdot R_t^E Q_{k,t-1} K_t \end{aligned}$$

$$S_t R_t^* (\Psi_t B_t^* + L_t^E + L_t^H) - S_t (B_{t+1}^* + L_{t+1}^E + L_{t+1}^H) = S_t P_t^* X_t - S_t P_t^* Y_t^M \quad (4.41)$$

Where the nominal foreign interest rate, R_t^*, is taken as given by the small open economy.

4.1.6 Monetary and fiscal policy

Government in this setting is in charge of conducting monetary and fiscal policy. As for the latter, the government simply aims at maintaining fiscal balance:

$$G_t = T_t^R + T_t^{NR} \quad (4.42)$$

The general form of the rule used by the central bank to conduct monetary policy is:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y} \left(\frac{S_t}{S_{t-1}}\right)^{\rho_S} \left(\frac{L_t}{L_{t-1}}\right)^{\rho_L}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \quad (4.43)$$

Where ρ_π and ρ_Y are, respectively, the weights that the monetary authority places on deviations of inflation and output from the steady state and $\xi_{R,t}$ is a monetary policy shock. It is assumed that the central bank adjusts the nominal interest rate also in response to changes in the exchange rate and total credit growth, the latter obtained aggreagating loans granted to homeowners and entrepreneurs. However, setting the coefficients of the last two terms to zero, leads to a standard Taylor Rule. Furthermore, when $\rho_S \to \infty$, the central bank follows a pegged exchange rate. Finally, the monetary authority engages in interest rate smoothing whenever $\rho_R > 0$.

4.1.7 Exogenous processes

In the following analysis, three exogenous shocks are considered: aggregate technology (A_t), and perception of lenders on homeowners and entrepreneurial productivity

(υ_t^H and υ_t^E). In particular, the latter two shocks are used as a proxy for capital inflows shocks to the small open economy. An increase in υ_t^H and υ_t^E, i.e. an increase in foreign lenders' perception of domestic borrowers' productivity, leads to a lowering of the external finance premium in the sector hit by the shock, and hence an increase in the demand for loans, which is satisfied by foreign lenders and hence amounts to a capital inflow.

Focussing on these particular two shocks is interesting because while both expansionary in nature, they affect different sides of the credit market. The technology shock increasese firms' productivity and leads firms to expand production, increasing their capital demand. This, in turn, translates in an increase in the demand for credit of the entrepreneurial sector. While demand for foreign funds increases, so does entrepreneurial leverage, thereby worsening balance sheet conditions.[64] On the other hand, capital inflow shocks affect the supply side of credit. When foreign lenders become optimist regarding domestic borrowers' productivity, they loosen credit conditions demanding a lower external finance premium, which drives down leverage and encourages borrowing. Hence, while a domestic technology shock "pulls" foreign capital in the small open economy, the capital inflow shock is of a "push" nature.[65] Exogenous variables obey the following autoregressive processes:

$$\begin{aligned}
\log(A_t) &= \rho_A \log(A_{t-1}) + \xi_{A,t} \\
\ln(\upsilon_t^H) &= \rho_\upsilon \ln(\upsilon_{t-1}^H) + \xi_{\upsilon,t}^H \\
\ln(\upsilon_t^E) &= \rho_\upsilon \ln(\upsilon_{t-1}^E) + \xi_{\upsilon,t}^E
\end{aligned}$$

4.1.8 Calibration

[64] We will see in the next section that, in case of foreign borrowing, the increase in leverage is partially offset by the exchange rate appreciation.

[65] See Fernandez-Arias (1996) for the introduction of the "push-pull" terminology in the context of capital inflows.

The calibration of the model parameters is largely drawn from existing studies on small open economies. In particular, I set the discount factor $\beta = 0.99$, implying an annual risk-free interest rate of 4%. The intertemporal elasticity of substitution (σ) is set to 1, so as the elasticity of labor supply (φ) following Christiano, Eichenbaum, and Evans (1997). In order to obtain a steady state labor supply of 0.33 the coefficient on labor in the utility function (χ_N) is calibrated at 8.8394. Regarding the composition of consumption, I set the share of imported goods in the consumption basket at 0.4, consistent with the value set for Latvia by Ajevskis and Vitola (2011), which implies some degree of home bias. Furthermore, I set the consumption habit parameter at 0.8, following the estimates for Estonia by Gelain and Kulikov (2009). As in Aoki, Proudman and Vlieghe (2004) and Forlati and Lambertini (2011), the elasticity of substitution between consumption and housing services is set to 1. The same value is chosen for the elasticity of substitution between domestic and foreign goods in the consumption basket, following Gertler, Gali' and Natalucci (2003). Furthermore, I set the share of housing services in the consumption bundle ($1 - \gamma_c$) to 0.0950, so that in steady state, the imputed rents to consumption ratio is equal to 10.5, which is consistent with pre-crisis data of Central and Eastern European countries.[66] Setting a depreciation rate for the housing stock (δ_h) to 1% annually results to a steady state housing investment to output ratio of 1%, which is consistent with the average of $1,06\%$ observed in the data.[67]

Turning to the production side of the economy, I set the elasticity of substitution between different varieties of domestic goods to 6, implying a price markup of 20%. Following Ajevskis and Vitola (2011) and Merola (2010), I set the same elasticity of substitution for different varieties of labor. Furthermore, I set the price and

[66] The ratio has been calculated dividing imputed rents by total consumption expenditures, for the period 2003-2007 (Eurostat data).

[67] Here, I used Eurostat data on gross capital formation in the construction sector as a proxy for investment the real estate sector. Again, the average is computed over the period 2003-2007.

wage stickiness parameters to 0.75, implying that prices and wages are adjusted, on average, every 4 quarters. The share of capital in production, α, is set to 0.35. Furthermore, the share of homeowners' and entrepreneurial labor in production is set to 0.01.

The parameters in the benchmark model calibration are set following Bernanke, Gertler and Gilchrist (1999). In particular, the standard deviation of the idiosyncratic productivity shock of homeowners and entrepreneurs (σ^H and σ^E) are set to 0.28. The monitoring cost parameters are calibrated at 0.12, implying a quarterly default probability of homeowners and entrepreneurs of 0.87% (3.48% annually). This results in an external finance premium equal to 228 basis points on an annual basis and in a steady state leverage ratio of 0.5. I can then back out the survival probability of entrepreneurs, which is calibrated at 0.98. The elasticity of the transfer from homeowners to consumers is calibrated at 0.0526.[68]

Finally, the standard deviation of the technology shock is set to 1, whereas that of the two perception shocks is set to 1%. All three shocks share the same persistence parameter, equal to 0.9.

4.2 Simulation Results

In what follows, I illustrate the dynamic evolution of the main model's variables in response to technology and capital inflow shocks, under different specifications of the Taylor rule. First, this exercise allows to shed light on the interplay between financial frictions in both the financing of capital and real estate investment, and

[68] While, for firms, this calibration is largely consistent with the values set by Ajevskis and Vitola (2011) for Latvia, they report much higher leverage ratios for the household sector. Hence, I also calibrate the model in order to deliver a higher leverage ratio (equal to 2.5) of homeowners. This amounts to setting the monitoring cost and the idiosyncratic volatility parameters to 0.18 and 0.2053 respectively. While the steady state default probability is unchanged, the steady state external finance premium rises to 340 basis points annually. This, however, does qualitatively alter the results.

analyze the transmission of shocks across sectors. Secondly, it will allow comparison between different monetary policy rules, illustrating their effect not only on output and inflation, but also on credit variables and their interactions across sectors.

I consider four Taylor rules obtained as special cases of equation (4.43). In the first scenario, the central bank sets the interest rate according to a standard Taylor rule, reacting to deviations of output and inflation:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{4.44}$$

Where variables without time subscript refer to steady state values (in particular, I set $\rho_\pi = 1.5$, $\rho_Y = 0.5$ and $\rho_R = 0.8$).

The second rule I consider is one in which the central bank sets the nominal interest rate reacting to a financial aggregate. The issue is then to choose what financial indicator is more appropriate for inclusion in the central bank's Taylor rule. Evidence presented by the IMF (2009) finds common patterns in economic variables in the period preceding an asset price bust. In particular, significant expansions in domestic credit and investment accompanied by current account deficits have been found to be recurrent in the run-up to a bust. Agénor and Pereira da Silva (2011) argue that in the context of middle income countries, central banks should conduct monetary policy by reacting to the economy's credit growth gap. They claim that, in so doing, the central bank can offset the acceleration mechanism that leads to credit growth and asset price inflation that is at the heart of financial imbalances. In particular, during upturns, informational asymmetries between borrowers and lenders are enhanced, and the prevailing loosening of lending standards erodes the resilience of the country to financial distress. Furthermore, studies as Claessens et al. (2011) and Calderón and Fuentes (2011) affirm that credit aggregates are useful leading indicators of asset price bubbles. In particular, while credit booms are not necessarily conducive of a crisis, the evidence suggests that almost all crises are preceded by a credit boom.

Hence, I consider a scenario where the central bank monitors the growth in loans in addition to output and inflation when setting the policy rate[69]:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y} \left(\frac{L_t}{L_{t-1}}\right)^{\rho_L}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{4.45}$$

The third policy rule considered represents a situation where the central bank reacts to exchange rate movements. Rules of this kind have been widely considered for small open economies with a high degrees of dollarization, especially in light of the fact that many emerging economies engaged in exchange rate stabilization or opted for a fixed exchange rate regime. In particular, the main argument for exchange rate stabilization in this context relies on the fact that, when debt is denominated in foreign currency, exchange rate fluctuations affect the economy not only through trade, but also through balance sheet effects on borrowers.[70] In this context, an exchange rate appreciation that, on one side, reduces exports with negative effects on aggregate demand, relaxes credit conditions of indebted agents, thereby stimulating further borrowing. Studies in this field[71] find that the suboptimality of exchange rate stabilization as a monetary policy strategy is strictly connected with the degree of openness of the economy (Devereux, Lane and Xu (2006)) and the source of the shock (Faia (2010)).

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi} \left(\frac{Y_t}{Y}\right)^{\rho_Y} \left(\frac{S_t}{S_{t-1}}\right)^{\rho_S}\right]^{(1-\rho_R)} \exp\left(\xi_{R,t}\right) \tag{4.46}$$

Here, the central bank reacts to devaluation pressures with a coefficient $\rho_S = 1.5$.[72]

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[69] Here, I set $\rho_\pi = 1.5$, $\rho_Y = 0.5$, $\rho_R = 0.8$ and $\rho_L = 1.5$.

[70] Krugman (1999), Aghion, Bacchetta, and Banerjee (2001).

[71] Cespedes (2000), Cespedes, Chang and Velasco (2004), Devereux, Lane and Xu (2006), Gertler, Gilchrist and Natalucci (2007), Batini and Levine (2008), Faia (2010).

[72] The coefficients on credit growth and exchange rate depreciation in the Taylor rules are set to the

Finally, I consider the case in which the central bank pursues a fixed exchange rate regime, obtained setting $\rho_S \to \infty$:

$$\Delta S_t = 0 \tag{4.47}$$

4.2.1 Domestic technology shock

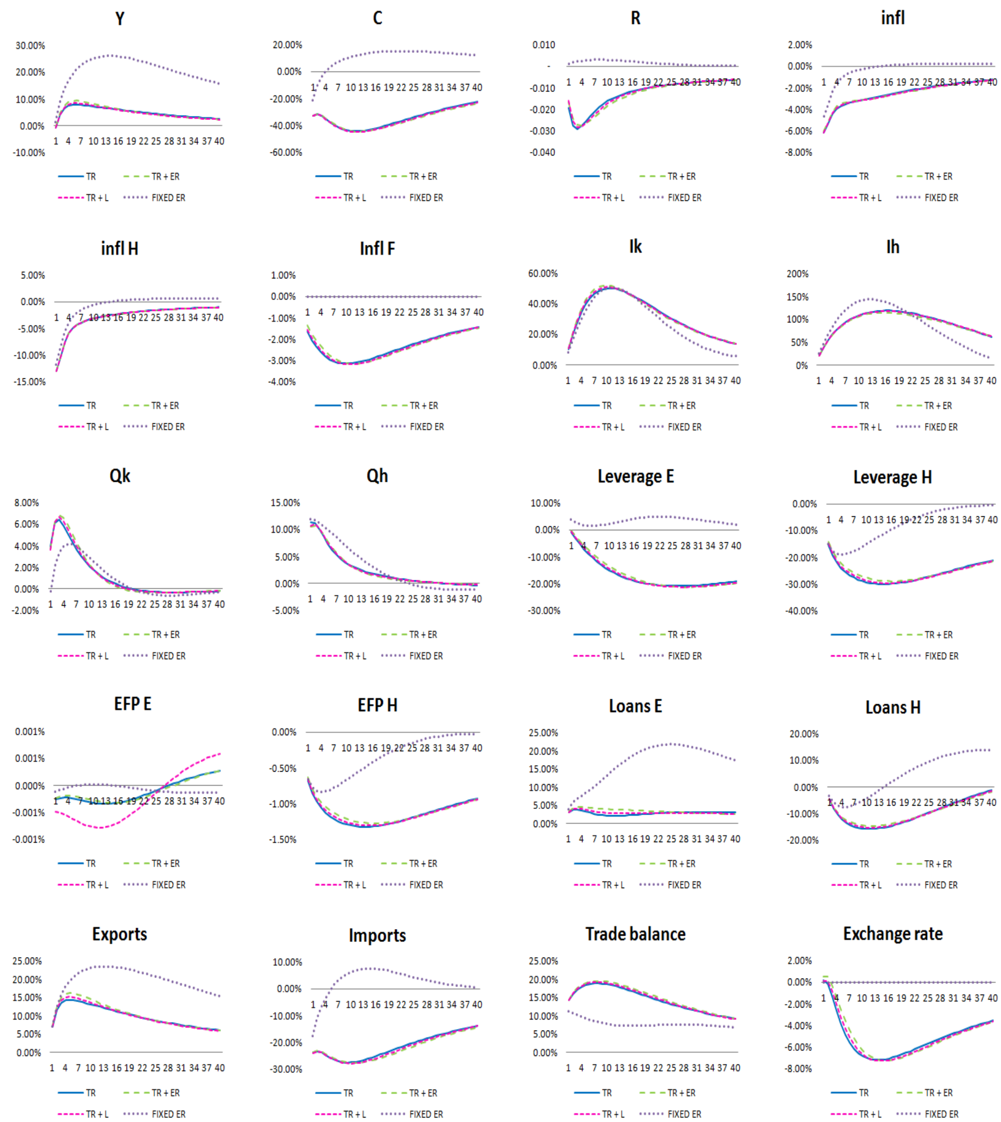
A positive, one standard deviation technology shock (depicted in Figure 4.1) implies an unexpected improvement in domestic firms' productivity and an abatement of marginal costs. On one side, this leads to a decreased demand for labor which drives down employment and wages. The resulting decrease in labor income depresses households' consumption of both goods and housing services. On the other hand, the reduction in marginal costs leads firms to revise prices downwards, lowering home goods inflation. The decline in the price of domestic goods has two consequences on external balance. As domestic goods are cheaper, on one side export demand rises, and on the other hand a substitution effect kicks in, which shifts domestic purchases towards home produced goods, causing a decrease in imports. As a result, the trade balance shifts to surplus, and the resulting net inflow of currency puts appreciation pressures on the exchange rate. The reaction of the central bank depends on the chosen monetary policy strategy. If the central bank follows a fixed exchange rate regime, it keeps the nominal interest rate unaltered; if it follows a Taylor rule, it lowers the nominal interest rate in response to the decrease in inflation.

The overall macroeconomic adjustment and the behavior of financial variables in both the entrepreneurial and the homeowners' sector crucially depend on the monetary policy regime, mainly through its effects on aggregate demand and on borrowers' balance sheets. Concerning aggregate demand, the domestic technology shock

same value, equal to 1.5, to enhance comparability between responses across different specifications of the monetary policy rule.

exerts opposite effects on the demand of consumption goods and housing. While improved productivity leads to a decrease in firms' demand of labor and hence a drop in wages, dampening domestic consumption (including housing services), external demand offsets the decline in consumption and boosts production, increasing firms' demand for capital. Hence, while demand for capital investment rises, demand for real estate investment contracts. Furthermore, it is important to notice that under a fixed exchange rate regime, the increase in export demand is much more pronounced, leading to a sharper expansion in production leading firms to limit their cutback in labor demand, which counteracts the fall in domestic consumption through a more muted decline in wage income. In any case, as capital demand surges, entrepreneurs engage in more projects, demand more credit and more unfinished capital goods, pushing up their price. While the raise in credit demand puts upwards pressures on entrepreneurial leverage, the increase in the price of capital partially offsets the worsening of entrepreneurs' balance sheet.

Figure 4.1: Responses to a domestic technology shock under different Taylor rules



Note: Responses to a one standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

However, the monetary policy regime directly affects credit markets through balance sheet effects arising from exchange rate fluctuations. The exchange rate appreciation occurring when the central bank follows a taylor rule decreases the effective debt burden of entrepreneurs and homeowners. In the entrepreneurial case, this counteracts the increased demand for loans by lowering the (foreign currency) value of debt, pushing leverage below steady state values and lowering the external finance premium. In the fixed exchange rate case, the favorable exchange rate effect does not occur, hence the loan burden increases, and with it entrepreneurial leverage, dampening the overall acceleration and leading to a smoother increment in capital investment. Hence, the interaction between monetary policy regime and credit frictions affects entrepreneurs through two effects acting in opposite directions. A fixed exchange rate regime boosts exports but dampens the financial accelerator mechanism. An inflation targeting regime limits the effect of external demand, but strengthens the financial accelerator.

The balance sheet effect on homeowners operates in a similar fashion. Under flexible exchange rate, the loan burden decreases, thereby leading to lower leverage and external finance premium for homeowners and encouraging new real estate projects that ultimately reduce the rental price of houses. Hence, the positive balance sheet effect is able to offset the initial decrease in housing demand caused by the drop in overall consumption, leading to increased housing investment. In the case of a fixed exchange rate regime, a similar positive effect on real estate investment occurs, but for different reasons. Here, the increase in export demand leads domestic firms to reduce employment by less, implying a more muted effect on households' wage income and hence a smoother drop in consumption. Hence, demand for housing services decreases less markedly. Hence, loan demand from homeowners declines by less, as well as leverage and the external finance premium, leading to an increase in housing investment that is even higher than in the case of flexible exchange rate. Hence, also in the case of homeowners, the interaction between monetary policy regime and credit frictions exerts two effects acting in opposite directions. A fixed exchange rate regime impacts less on housing demand but dampens the financial accelerator mechanism. An inflation targeting regime implies a greater fall in rental housing demand, but strengthens the financial accelerator.

Hence, in the event of a technology shock, credit frictions at the entrepreneurial and homeowners' level can lead to different scenarios concerning the co-movement of financial variables in the two sectors depending on the monetary policy regime. Under a fixed exchange rate regime, albeit a positive co-movement of investment and asset prices in the two sectors, financial variables exhibit a negative correlation. While external finance premia and leverage increase in the entrepreneurial sector, they decrease in the real estate sector. On the contrary, under a flexible exchange rate regime as in the three taylor rules considered, financial variables co-move following a technology shock. While in both cases the shock exerts an opposite effect on the demand for goods (positive) and housing services (negative), in the flexible exchange rate regime, the balance sheet effect is able to offset the increase in leverage caused by the increased loan demand, while this effect does not operate in the case of pegged currency.

Finally, it is worth noting how the three considered Taylor rules do not imply large differences in the dynamic adjustment of real and financial variables. This is a direct consequence of the pattern of co-movement between financial variables in the entrepreneurial and homeowners' sectors. Following the shock, while entrepreneurs demand more credit, homeowners do not and, as a result, aggregate credit does not increase so much to warrant a stronger reaction of the central bank.

4.2.2 Capital inflow shock: entrepreneurs

Figure 4.2 depicts the responses to a positive increase in foreign lenders' perception of entrepreneurs' productivity under the three Taylor rules and fixed exchange rate scenarios. As foreign lenders become more optimist concerning the profitability of entrepreneurs, implying a smaller perceived probability of default, they loosen credit conditions. Hence, on impact, the external finance premium charged on domestic entrepreneurs decreases. As borrowing conditions improve and entrepreneurial net worth rises, leverage declines. Therefore, the abatement of the cost of external finance prompts entrepreneurs to engage in new investment projects, and to demand more credit. As capital investment increases and with it the supply of capital, production surges, and so does domestic price inflation. Furthermore, the positive inflow of capital exerts appreciating pressures on the domestic currency (the exchange rate decreases). After this impact effect, the macroeconomic adjustment crucially depends on the monetary policy rule followed by the domestic central bank. Under any Taylor rule, implying a flexible currency, the exchange rate appreciation leads to a decrease in the price of imports, which offsets the increase in domestic price inflation and leads to a decline in CPI inflation. Under an inflation targeting regime, as output rises above steady state values more than inflation contracts, the central bank raises the policy rate, thereby accommodating the exchange rate appreciation after the initial impact. While this doesn't improve the country's export performance, it has positive consequences on borrowers' balance sheet and it is the key channel of transmission of the shock to the real estate investment sector. In fact, as the exchange rate appreciates, borrowing conditions of homeowners improve. As the debt burden decreases, and with it the external finance premium and leverage, investment in the real estate sector grows. Hence, the positive effect of the initial shock to entrepreneurs' borrowing conditions positively spills over to homeowners through balance sheet effects, leading to a positive co-movement of financial variables across sectors. If the central bank engages in exchange rate targeting, it tries to offset the initial exchange rate appreciation and increases the nominal interest rate by a smaller amount. While this reduces the negative effect on exports and boosts aggregate demand, it somewhat dampens the positive balance sheet effect. However, even in this case the shock positively spills over to homeowners leading to an increase in housing investment and prices.

Figure 4.2: Responses to a one standard deviation capital inflow shock (entrepreneurs), under different Taylor rules

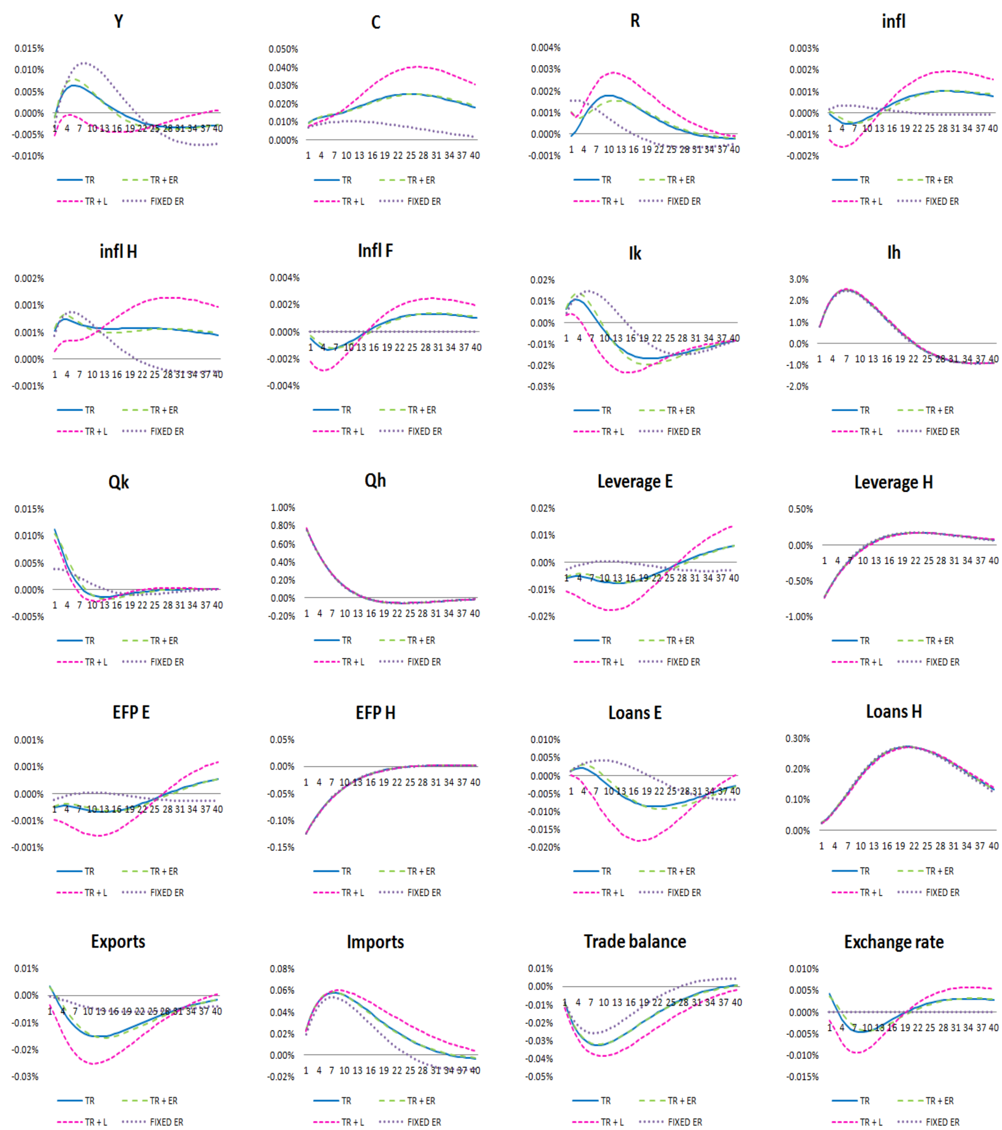
Note: Responses to a one standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

In case the Taylor rule reacts to credit growth involves a stronger monetary policy contraction. As the capital inflow shock boosts entrepreneurial demand for credit and the balance sheet effect on homeowners' debt is not strong enough, overall credit growth rises. The increase in inflation and in agregate loans growth prompts the central bank to increase the interest rate. However, in case of foreign currency borrowing, the relevant opportunity cost of investment is the foreign interest rate, which is taken as given by the small open economy and stays constant. As the monetary policy tightening results in a stronger exchange rate appreciation, it strengthens borrowers' balance sheets, leading to a sharper decrease in leverage and a stronger improvement in balance sheet conditions. Furthermore, the stronger currency appreciation harms competitiveness, leading to a more pronounced fall in export demand which offsets the increase in output driven by the rise in domestic demand.

4.2.3 Capital inflow shock: homeowners

Figure 4.3 reveals that the effect of a capital inflow to the homeowners' sector implies a similar macroeconomic dynamics as a shock to credit to entrepreneurs. On impact, the shock reduces the external finance premium paid on real estate mortgages, thereby increasing the net worth of homeowners and reducing their leverage. As homeowners find it more convenient to invest in real estate projects, investment in the housing sector increases and house prices rise. The shock has a positive effect on overall consumption through three effects. On one side, the rise in housing prices boosts households' wealth, encouraging consumption. On the other hand, the increased supply of finished housing lowers their rental price, boosting demand. Finally, as the domestic currency appreciates, imports become cheaper and overall CPI inflation declines, stimulating purchases. The increased demand for domestic goods for consumption and housing investment purchases stimulates production, which leads to a raise in demand for capital goods. Hence, as returns to capital increase, the entrepreneurial sector is stimulated to undertake new investment projects. While this increases leverage and the external finance premium under a fixed exchange rate regime, if the central bank follows a Taylor rule, the appreciation of the domestic currency exerts a favorable balance sheet effect on entrepreneurial leverage. However, once again, when the central bank reacts to credit growth, the increase in the domestic interest rate is stronger, leading to a sharper decrease in exports which depress demand. In this case, production remains below steady state for quite some time after the shock. As a result, in spite of the decrease in entrepreneurial leverage, capital investment is negatively affected by the decline in capital demand by firms. On the contrary, when the central bank engages in exchange rate smoothing, it prevents a sharp fall in exports while still allowing for a positive balance sheet effect arising from the currency appreciation. Hence, the growth in domestic demand is able to compensate the fall in foreign demand, leading to an expansion of production.

Figure 4.3: Responses to a one standard deviation capital inflow (homeowners) shock, under different Taylor rules



Under the fixed exchange rate regime, the value of the currency is kept constant. This implies that the consumer price index does not benefit from the effect of the exchange rate appreciation, as the price of foreign goods is not affected. This, combined with the increase in domestic prices due to demand pressures implies that overall consumer price inflation rises. Furthermore, as the exchange rate does not appreciate, exports are only affected to the extent that the price of domestic goods rises. However, the fall in exports is negligible, and does not significantly counteract the increase in domestic demand, leading to higher production and hence higher capital investment. Furthermore, as balance sheet effects of exchange rate fluctuations are absent in this setting, entrepreneurial borrowing conditions are worse than in the case of flexible currency. Therefore, after an initial decrease in leverage and premium due to the increase in asset prices, as capital investment peaks leverage rises, albeit to a small extent. Hence, once again the exchange rate regime determines the extent of co-movement between sectorial borrowing conditions in the small dollarized economy. While a monetary regime implying a flexible exchange rate leads to positive co-movement, when the currency is pegged, the correlation weakens and slightly reverts direction.

4.3 Optimal monetary policy

In this section, I compute the optimal unrestricted optimal rule for the presented small open economy subject to productivity and capital inflow shocks. I assume the central bank's objective is represented by a quadratic loss function, which the monetary authority attempts to minimize. I consider different scenarios according to the objectives of the central bank. In the first setting, the central bank is only concerned about stabilizing the real economy, and attempts to avoid excessive fluctuations in output and inflation. In a second setting, the monetary authority also cares about financial stability and considers fluctuations in loans growth undesirable.

The optimal monetary policy strategy with respect to financial stability issues has since long been a contentious issue, which has intensified with the eruption of the global financial crisis. The fact that the primary objective of a central bank should be price stability is widely accepted and remains unchallenged. However, the view that the central bank should only be concerned with price stability has been challenged in the last decade, on the grounds of the inherent fragility of the financial system. On one side, it is claimed that by always pursuing the goal of price stability central banks will in fact best promote financial stability (see for example Bernanke and Gertler (1999) and Cogley (1999)), whereas a separate weight on financial stability considerations in the monetary policy objective is likely to have destabilizing effects on the economy. In most recent years, however, the unicity of the traditional objective of monetary policy has been more strongly put into question, on the grounds that an environment of low inflation and sustained economic growth might not be sufficient to guarantee financial stability. In particular, it has been argued that asset price bubbles and excessive credit growth might occur as a consequence of stable inflation expectations and optimistic prospects about the future economic outlook, which encourage risk taking and financial fragility. Among the advocates of this view are Cecchetti et al. (2000), Borio and Lowe (2002 and 2004), Bordo and Jeanne (2002), White (2006) and Woodford (2012). Their argument rests on the claim that setting monetary policy only considering developments in inflation and the output gap might be a too narrow approach, and that better results in terms of stabilization could be achieved by explicitly targeting unsustainable increases in asset prices and excessive credit growth, even at the cost of increased variability in inflation and output. In particular, it is argued that ensuring a stable path of credit growth is conducive of both financial stability (through reduced swings in asset prices and sustainable leverage dynamics) and macroeconomic stability (hampering excessive fluctuations in consumption and investment). More specifically, Woodford (2012) argues that the monetary policy trade-off between inflation and financial stability is very similar to that between inflation and output stabilization and that central banks might be able to strike a balance between the two objectives by means of a form of "flexible inflation targeting regime". The validity of a central bank's financial stability objective from a welfare standpoint has been emphasized by Angeloni and Faia (2013). By making a quantitative comparison of welfare under different central bank's objectives, they conclude for the appropriateness of financial stability being included as one of such objectives.

In what follows, I consider three specifications of the monetary authority's preferences. First, I consider a central bank which aims at macroeconomic stability, thereby trying to limit fluctuations in inflation and output. Furthermore, the central bank considers desirable to limit the volatility of the domestic interest rate. Hence, the loss function in this first instance is defined as follows[73]:

$$L^{MS} = E_t\left[\hat{\pi}_t^2 + \lambda_y \hat{Y}_t^2 + \lambda_r \hat{R}_t^2\right] \tag{4.48}$$

Where variables with a hat denote log deviations from steady state values. λ_y represents the relative weight the central bank places on output stability relative to inflation stability, and λ_r denotes the relative weight on interest rate variability.

In the second scenario, I consider a central bank also concerned with financial stability. In this setting, I specify the central bank's loss function as being a positive function of the volatility of aggregate credit growth in addition to output, inflation and interest rate volatility. In this case, the loss function is defined as:

$$L^{FS} = E_t\left[\hat{\pi}_t^2 + \lambda_y \hat{Y}_t^2 + \lambda_r \hat{R}_t^2 + \lambda_L (L_t/L_{t-1})^2\right] \tag{4.49}$$

In particular, I consider two specifications of the loss function with financial stability objective, according to the central banks' relative preference for macroeconomic versus financial stabiliy. In the first case, which I denote L_1^{FS}, the monetary authority of the small open economy considers monetary stability a priority, which translates in a lower weight on credit growth. Specifically, I set $\lambda_L = \lambda_y = 0.1$. The

[73] In particular, I set $\lambda_y = 0, 1$, $\lambda_r = 0.05$.

second specification corresponds to the case in which the central bank considers the macroeconomic stability and the financial stability objectives equally important. I denote the loss function corresponding with this case with L_2^{FS}, which is characterized by a weight on credit growth volatility equal to 1.

In what follows, I assume the economy is affected by the three considered shocks (i.e. domestic technology, and foreign lenders' perception of domestic entrepreneurs' and homeowners' productivity) at the same time. The calibration of the shock is similar to that used for the impulse response functions analysis, i.e. one standard deviation technology shock and 1% positive perception shocks. The optimized Taylor rule coefficients and the corresponding value of the loss functions are presented in Table 4.1[74].

Table 4.1: Optimized Taylor rule

	φ_r	φ_π	φ_y	φ_L	φ_S	$Loss$
Loss MS	0.7620	1.3659	0.7447	0.099	0.088	0.4526
Loss FS_1	0.7752	1.3615	0.7592	0.099	0.4826	0.4550
Loss FS_2	0.7818	1.373	0.7273	0.0997	0.487	0.4681

In all cases the coefficient on lagged interest rate reveal a quite high optimal inertia of the monetary policy rule. Given that, in the model, the relevant risk free rate for lenders is the foreign one, this result might be puzzling. However, in a small open economy, changes in the nominal interest rate are mirrored by exchange rate fluc-

[74] Optimal Taylor Rule coefficients are obtained implementing the "osr" (optimal simple rule) procedure in Dynare, which relies on the csminwel.m numerical algorithm provided by Chris Sims. The algorithm performs a numerical optimization of the objective function (the central bank's loss function) based on the Quasi-Newton implemented through the BFGS (Broyden–Fletcher–Goldfarb–Shanno) algorithm. Here, the iteration procedure will cease when it proves impossible to improve the function value by more than 1e-7. The algorithm found a solution after 7 iterations for Loss MS and Loss FS_1, and after 6 iterations for Loss FS_2.

tuations, which impact the balance sheet of borrowers with foreign currency debt, leading to more volatility in financial variables, including credit growth. Therefore, even when the central bank is not concerned about financial stability, it considers desirable to smooth movements in the monetary policy rate. The optimized coefficients on inflation and output are broadly similar across loss function specifications. While going from L^{MS} to L_1^{FS} the optimal weight on inflation increases, that on output decreases, but these differences are of negligible importance. The most important result emerging from Table 4.1 concerns the optimized coefficients on aggregate credit growth and exchange rate stabilization. In the case the monetary authority is not concerned with financial stability, both optimized coefficients are close to zero. In this case, reacting to inflation and output deviations is optimal. On the contrary, when financial stability considerations are included in the central bank's objective, the optimized coefficient on exchange rate depreciation is positive and equal to 0.48, while the optimized coefficient on credit growth is still close to zero. These results can be better understood referring to the impulse-response functions analysis presented in the previous section. In Figure 4.2, I presented the responses to a 1% shock to foreign lenders' perceptions of entrepreneurial productivity. Comparing the impulse responses for the Taylor rule with exchange rate stabilization and the Taylor rule with credit growth reveals the reason why reacting to credit growth is suboptimal. The perception shock leads foreign lenders to lower the price of credit, which encourages borrowing and hence credit growth. The central bank observes the increase in loans and tightens the domestic interest rate quite sharply. Hence the central bank reacts by increasing the policy rate by a larger amount than under a standard Taylor rule with exchange rate smoothing.[75] However, in case of foreign currency borrowing, the relevant opportunity cost of investment is the foreign interest rate, which is

[75] Note that the coefficients on exchange rate depreciation and credit growth in the simple Taylor rules are equal, so as to enhance comparability between the two monetary strategies.

taken as given by the small open economy and stays constant. As the monetary policy tightening results in a stronger exchange rate appreciation, it strengthens borrowers' balance sheets, leading to a sharper decrease in leverage and a stronger improvement in balance sheet conditions. Furthermore, the stronger currency appreciation harms competitiveness, leading to a more pronounced fall in export demand which offsets the increase in output driven by the rise in domestic demand. As a result, in pursuing such a monetary policy strategy, the domestic central bank obtains results that conflict with its objectives. First, it does not succeed in smoothing credit developments as the economy is dollarized: on the contrary, it strengthens borrowers' balance sheets. This encourages the build-up of financial vulnerabilities of the kind many Eastern European economies were exposed to before the crisis: overexpansion of foreign currency debt and increase in leverage. Second, it offsets the positive effect of export demand on output, counteracting the expansionary effect of the capital inflow shock. Hence, the central bank can achieve a better result in terms of macroeconomic and financial stabilization if it includes an exchange rate term in the Taylor rule, simultaneously smoothing the volatility of credit aggregates and containing the negative effects of the domestic currency appreciation on exports.

One natural question that arises is whether these results are driven by the relatively small magnitude of the capital inflow shocks compared to the technology shock. Would the monetary authority of an economy hit by large capital inflow shock find it optimal to react to credit aggregates? In Table 4.2, I present optimized Taylor rule coefficients for different calibrations of the perception shocks.

Table 4.2: Optimal Taylor rule for different magnitudes of the perception shocks

	φ_r	φ_π	φ_y	φ_L	φ_S	Loss
$\sigma_{ve} = \sigma_{vh} = 0.01$						
Loss MS	0.7620	1.3659	0.7447	0.099	0.088	0.4526
Loss FS_1	0.7752	1.3615	0.7592	0.099	0.4826	0.4550
Loss FS_2	0.7818	1.373	0.7273	0.0997	0.487	0.4681
$\sigma_{ve} = \sigma_{vh} = 0.1$						
Loss MS	0.7619	1.365	0.744	0.100	0.088	0.4528
Loss FS_1	0.775	1.3615	0.7595	0.099	0.481	0.4552
Loss FS_2	0.7816	1.373	0.728	0.100	0.487	0.4613
$\sigma_{ve} = \sigma_{vh} = 0.5$						
Loss MS	0.7583	1.3655	0.7492	0.1054	0.087	0.4562
Loss FS_1	0.7707	1.360	0.766	0.106	0.485	0.4612
Loss FS_2	0.7751	1.368	0.749	0.1149	0.4868	0.4887

As it can be noticed, optimized Taylor rule coefficients do not change much across specifications and are similar to the baseline. Increasing the magnitude of the perception shocks results in slightly higher reaction coefficients on all variables in the Taylor rule. Furthermore, even for 10% perception shocks, the optimal reaction coefficient to credit growth is small, albeit it slightly increases. However, even confronted with capital inflow shocks of greater magnitudes, a strong reaction of the central bank to credit developments is not optimal. Hence, a central bank equipped with only one instrument cannot adequately manage capital inflow surges, as a monetary tightening results in a strengthening of borrowers' balance sheets through exchange rate effects and an even higher demand for foreign loans. This warrants the establishment of macroprudential instruments, especially designed to counteract the surge in financial imbalances. The analysis of such issues requires expanding the present model to include a financial sector channeling foreign loans to domestic borrowers, which will be a subject of future work.

4.4 Robustness analysis and sensitivity to model assumptions

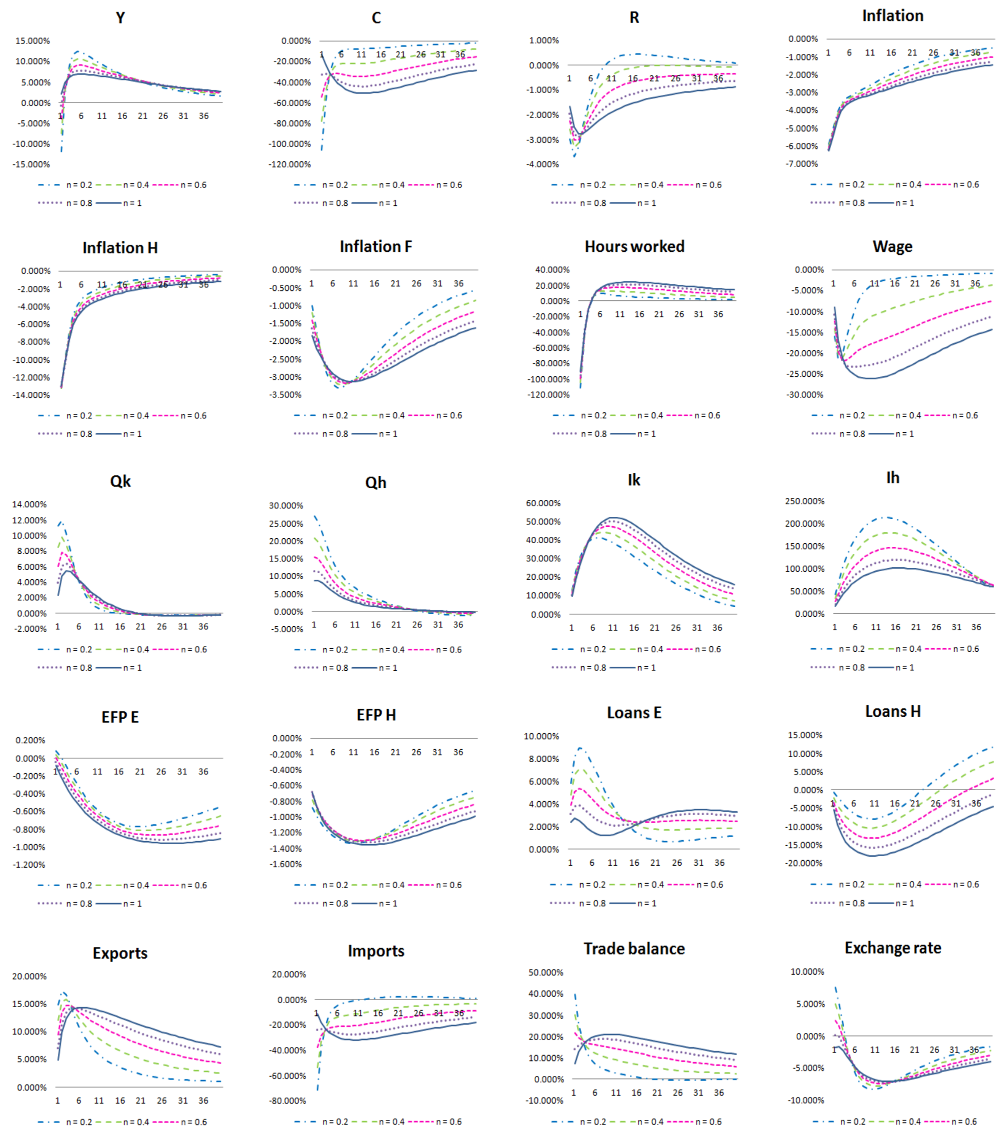
The model presented earlier is based on specific choices in the modeling framework and in the calibration of parameters. Three assumptions in the presented model could be considered of key importance for the relevance of the results.

First, to introduce homeowners and incorporate them to the household sector, it has been postulated that the consumers can behave either is a Ricardian or a Non-Ricardian fashion, with the share of Ricardian consumers set at 0.8. Secondly, it is assumed that homeowners are linked to Non-Ricardian consumers via a transfer scheme. In particular, in each period, homeowners perform a transfer to Non-Ricardian consumers, which depends on the inverse leverage ratio. Finally, the presented model assumes that homeowners and entrepreneurs borrow exclusively in foreign currency, i.e. the economy is characterized to full financial dollarization. In what follows, I explore the sensitivity of results to the composition of the consumers population and to the presence of the transfer scheme. The Appendix to this chapter presents a possible extension to the current framework allowing for borrowing in different currencies.

4.4.1 Importance of the composition of consumers on the model's dynamics

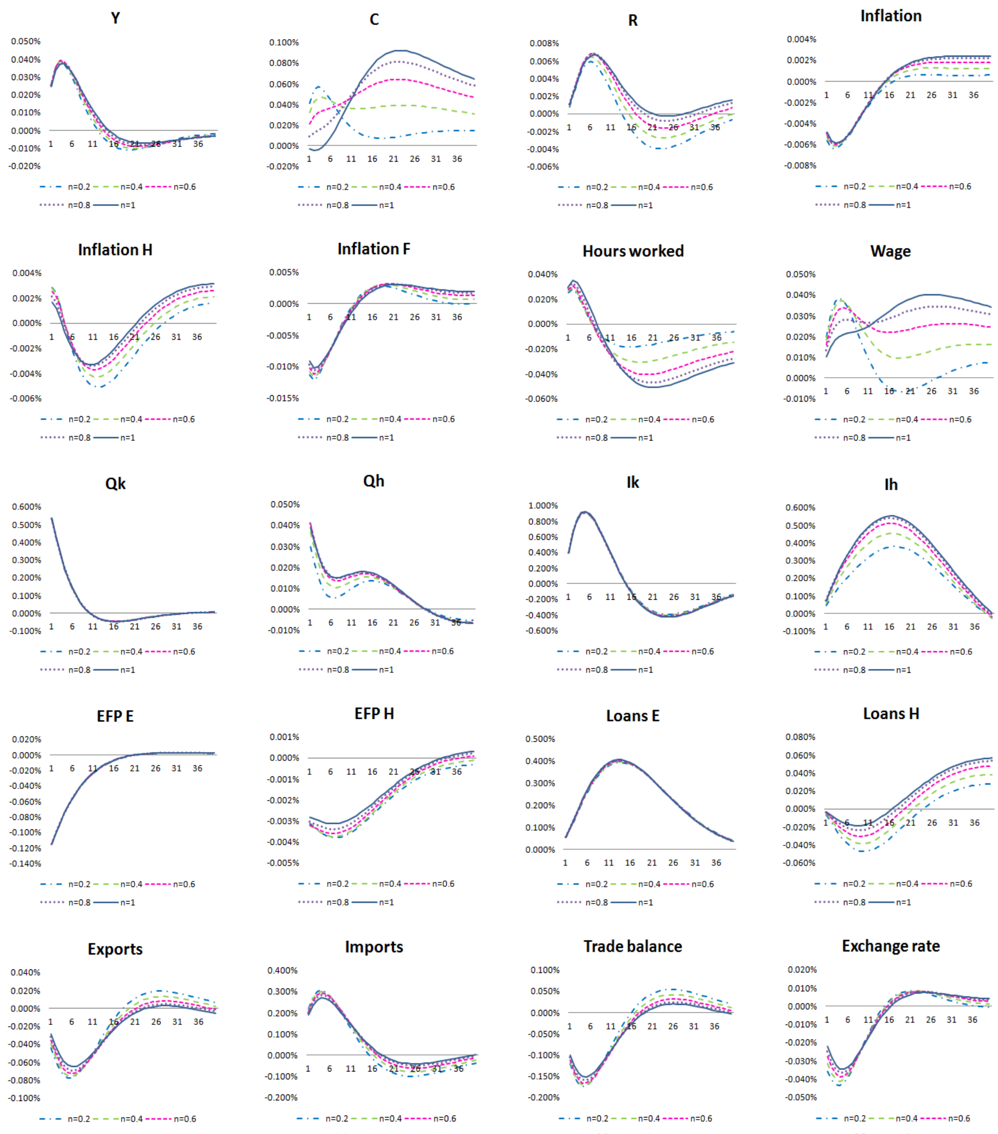
In what follows, I will present the impulse-response functions of the model obtained for different shares of Ricardian and Non-Ricardian households. In the model, n represents the share of Ricardian consumers, i.e. those consumers that solve an intertemporal optimization problem in each period, maximixing their utility subject to a budget constraint. The remaining $(1-n)$ consumers are Non-Ricardian, and they consume their full current income in each period, thus not operating an intertemporal choice. The depicted impulse-response functions refer to the case in which the central bank of the small open economy sets the policy rate following a standard Taylor Rule with a coefficient of 1.5 on inflation and 0.5 on output. I consider various values of n (specifically 0.2, 0.4, 0.6, 0.8 and 1), where the case $n = 1$ corresponds to a case where all consumers are Ricardian. I exclude the case where $n = 0$ because, in this instance, all consumers would be Non-Ricardian and there would be no optimal intertemporal allocation of consumption and saving over time. Hence, the interest rate would have no role in shaping consumption and saving decisions, and the model can no longer be solved.

Figure 4.4: Responses to a domestic technology shock under standard Taylor rule and different shares of Ricardian and Non-Ricardian consumers



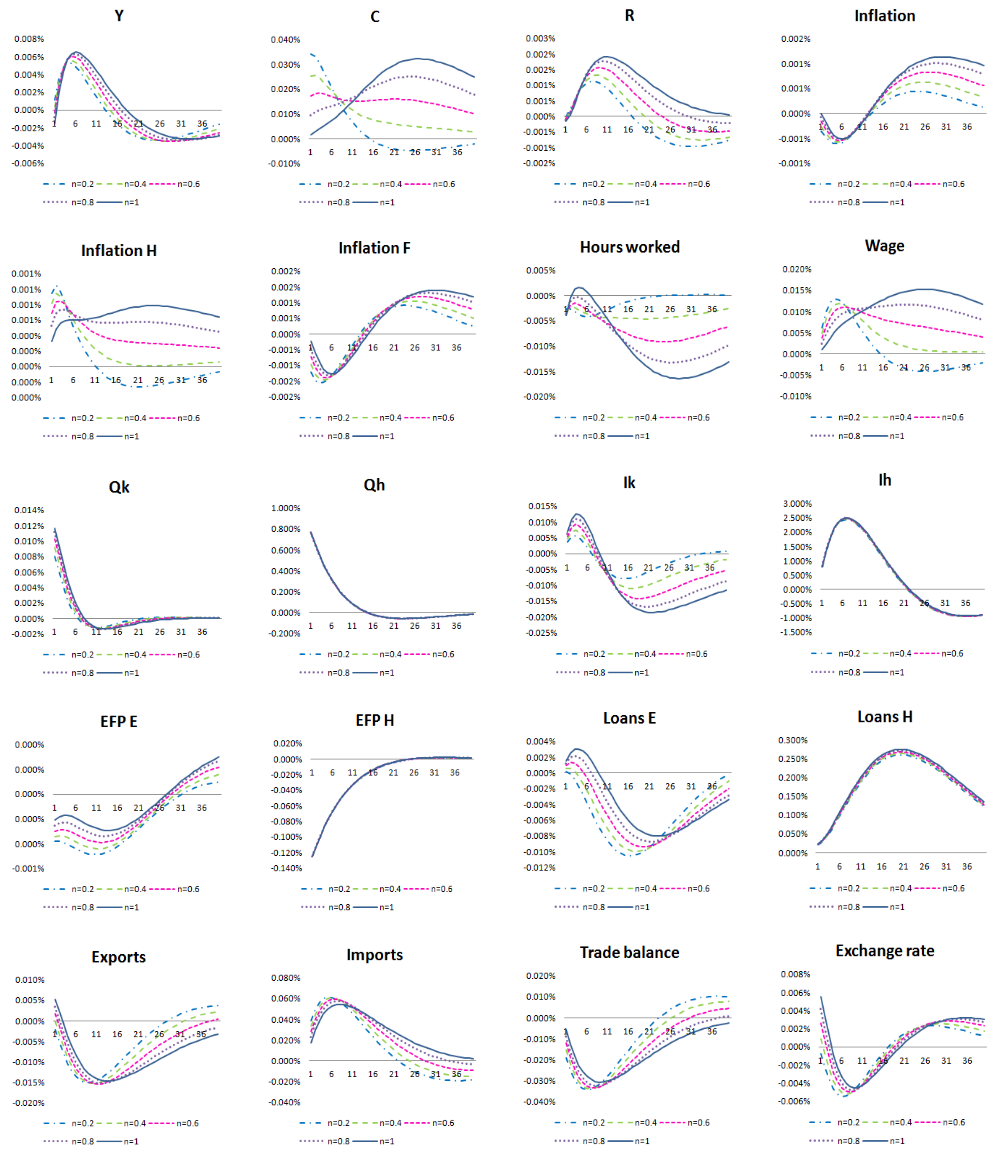
Note: Responses to a one standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.5: Responses to a capital inflow shock to entrepreneurs under standard Taylor rule and different shares of Ricardian and Non-Ricardian consumers



Note: Responses to a 0.01 standard deviation capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.6: Responses to a homeowners' capital inflow shock under standard Taylor rule and different shares of Ricardian and Non-Ricardian consumers



Note: Responses to a 0.01 standard deviations homeowners' capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Before discussing the impulse-responses, few remarks are in order. Ricardian consumers determine their optimal intertemporal allocation of consumption, savings and working hours. Non-Ricardian households do not operate these choices: instead, they consume their current income in each period, which consists of labor income, transfers from homeowners, net of taxes. As such, their consumption decisions are independent of the interest rate. As only Ricardian consumers operate consumption and labor decisions, they are those that determine the labor supply. As labor is assumed to be homegenous, Non-Ricardian consumers work the same hours and receive the same wage as Ricardian consumers.

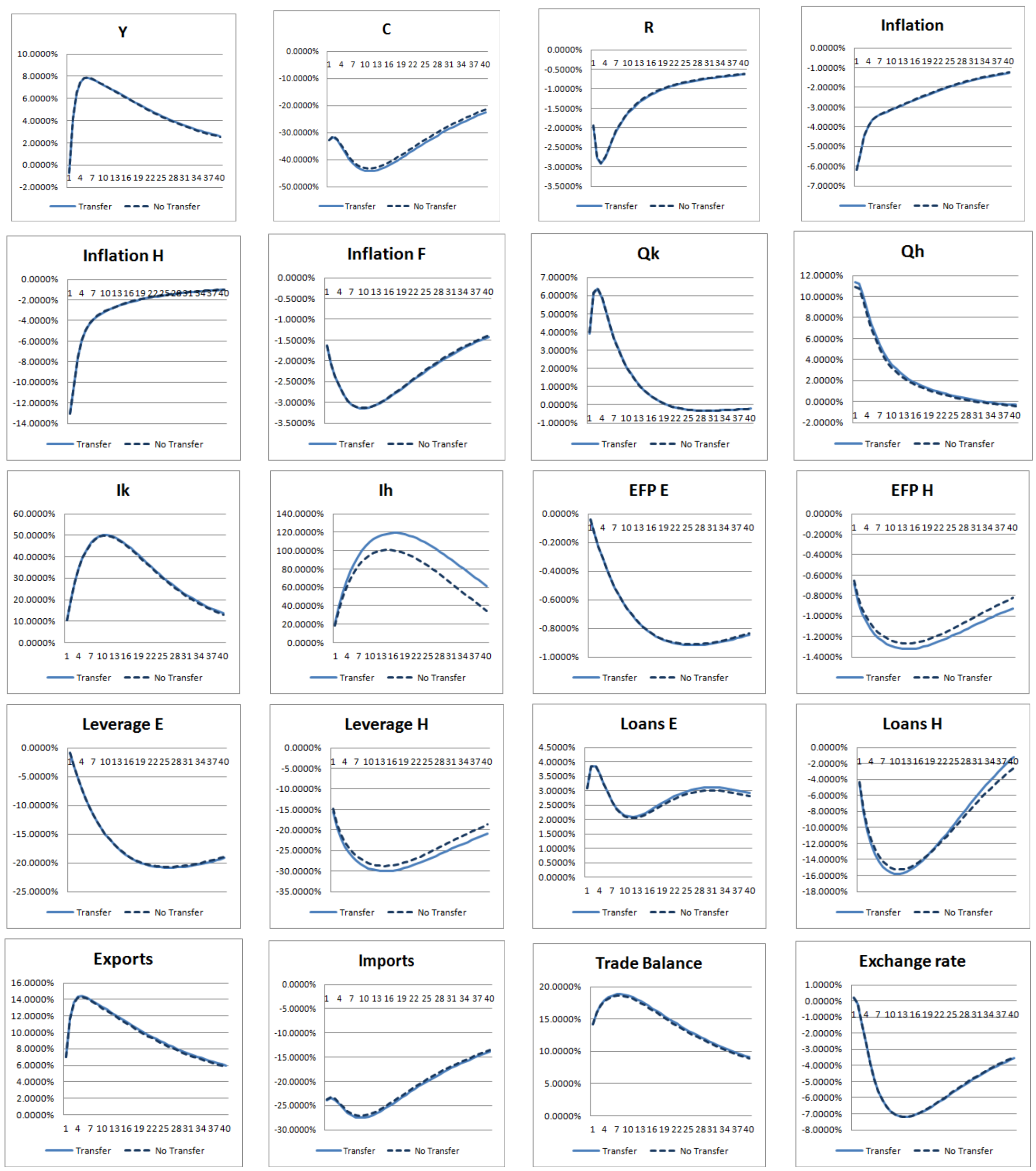
I will now discuss the case of a positive technology shock (depicted in Figure 4.4) to illustrate the dynamics of the model under different shares of Ricardian and Non-Ricardian consumers. The technology shock decreases marginal costs and firms' demand for labor, thereby putting downward pressures on wages. As we could expect, the effect of a decrease in employment and in the wage has stronger effects on consumption when the share of Non-Ricardian consumers is high ($n = 0.2$). Their consumption decreases sharply following the decrease in labor income. Consumption of Ricardian consumers also falls, but it does so much more smoothly. Why? Because, as the central bank lowers the interest rate in response to the decrease in inflation, Ricardian consumers substitute some savings with consumption, thereby mitigating its fall. Furthermore, it is important to notice that, the larger the share of Non-Ricardian consumers (i.e. the smaller n), the smaller the positive effect of the technology shock on output. While for $n = 1$ the technology shock leads to a persistently higher output, when n decreases output increases less and even decreases on impact for smaller values of n. This is due to the much stronger decline in domestic demand driven by the larger fall in consumption, which is not compensated by the increase in external demand. As a result of the stronger decline in output, the central bank decreases the policy rate more strongly when n is low, inducing a domestic currency depreciation which encourages exports and further discourages imports (imports decrease much more also because consumption falls more heavily when a large share of consumers are Non-Ricardian). The difference in the responses of financial variables are a direct consequence of the dynamics of output and the exchange rate for different values of n. Output influences the demand for capital, which influences investment in the capital sector and the variables related to entrepreneurs. The exchange rate directly influences leverage, impacting the external finance premium and financing conditions.

A similar discussion holds for the capital inflow shocks (depicted in Figures 4.5 and 4.6, so the main message we can draw from this exercise is that changing the share of Ricardian and Non-Ricardian consumers impacts on the model dynamics through the different behavior of consumption, which is more (less) sensitive to interest rate movements and less (more) sensitive to wage income when the share of Ricardian consumers is high (low).

4.4.2 Importance of the transfer scheme on the model's dynamics

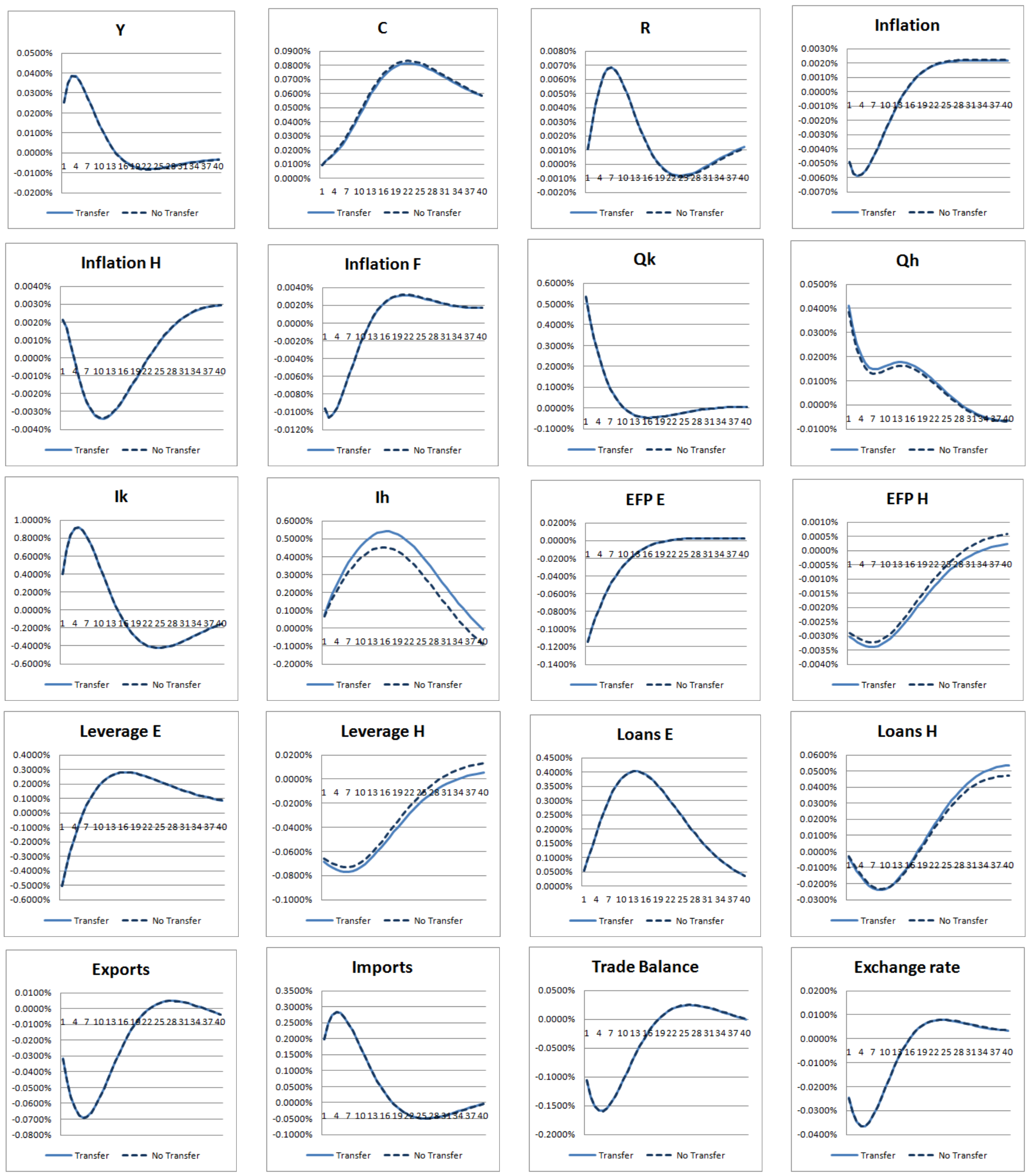
In this section, I quantify the effect of the presence of the transfer from homeowners to consumers on the dynamics of the model. To do so, I compare the behavior of the baseline model (which includes the transfer) to a model where the transfer is removed. Specifically, in the latter specification, I assume a homeowners behave as entrepreneurs: in each period, a fraction of homeowners exits the market and consumes the remaining net worth. It is important to notice, however, that, while removing the transfer, the distinction between Ricardian and Non-Ricardian consumers is conserved, so as to isolate the effect of the transfer. The impulse-response functions are depicted below, for the case in which the central bank sets the interest rate following a standard Taylor rule.

Figure 4.7: Responses to a domestic technology shock under standard Taylor rule. Comparison of model with and without transfer



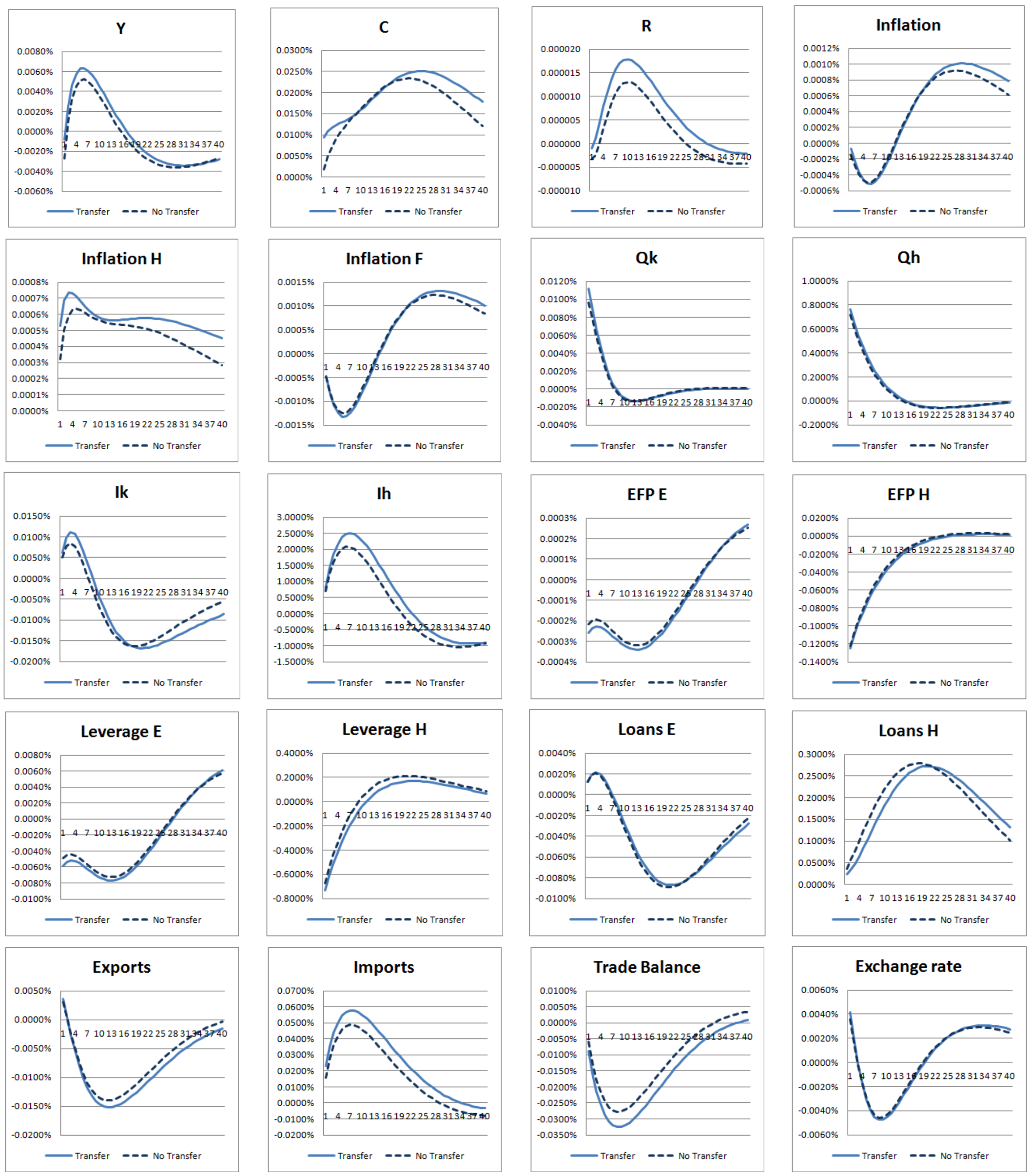
Note: Responses to a 1 standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.8: Responses to an entrepreneurs' capital inflow shock under standard Taylor rule. Comparison of model with and without transfer



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.9: Responses to a homeowners' capital inflow shock under standard Taylor rule. Comparison of model with and without transfer



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figures 4.7, 4.8 and 4.9 lead to two main conclusions. First, the presence of the transfer does not alter the response of the main macoreconomic variables: it exerts an effect on variables pertaining to homeowners, and impacts consumption only negligeably. Only in the case of a capital inflow shock affecting homeowners it is possible to notice some difference between a model with and without transfer. This happens because the shock directly affects the balance sheet of homeowners, and has a direct impact on the transfer homeowners remit to (Non-Ricardian) consumers. The positive capital inflow shock to homeowners lowers the external finance premium on impact and with it borrowing costs, having a positive impact on net worth. As net worth increases (and leverage decreases), the transfer increases as well, increasing the income of Non-Ricardian consumers. This extra income is used for consumption purposes, hence consumption increases more when the transfer is active. As consumption is allocated between domestic and imported goods, also imports increase by a larger amount in the model with the transfer. Higher consumption in the model with transfer is met by a stronger increase in output and, with it, a stronger increase in capital demand and in investment in capital goods. Furthermore, as consumption is allocated between goods and housing services, also the demand for the latter increases, thereby reinforceing the effect of the initial shock on homeowners' balance sheet and leading to higher investment in housing.

4.5 Conclusion

In this paper, I analyze the interplay between financial frictions at the household and firm level, liability dollarization and monetary policy in a small open economy subject to productivity and capital inflow shocks, motivated by the pre-crisis experience of many Eastern European countries where large inflows of capital directed to the financing of investment and mortgage loans resulted in the build-up of vulnerabilities in the financial sector. In particular, I focus on the interaction of firm and household leverage in the transmission of shocks to domestic technology and capital inflows, under three specifications of the monetary policy rule that have been widely considered in the literature for emerging economies (i.e. inflation targeting, exchange rate targeting and fixed exchange rate) and a Taylor rule reacting to credit growth. Furthermore, I compute the optimal unrestricted monetary policy rule under two specifications of the central banks' objectives, namely macroeconomic stability and macroeconomic plus financial stability.

I find that, first, regardless of the monetary authorities' preferences, the optimized coefficient on lagged interest rate reveal a quite high optimal inertia of the monetary policy rule. Given that, in the model, the relevant risk free rate for lenders is the foreign one, this result might be puzzling. However, in a small open economy, changes in the nominal interest rate are mirrored by exchange rate fluctuations, which impact the balance sheet of borrowers with foreign currency debt, leading to more volatility in financial variables, including credit growth. Therefore, even when the central bank is not concerned about financial stability, it considers desirable to smooth movements in the monetary policy rate.

A second result concerns the optimized coefficients on exchange rate depreciation and credit growth. In the case the monetary authority is not concerned with financial stability, reacting only to inflation and output deviations is optimal. When financial stability considerations are included in the central bank's objective, the monetary authority finds it optimal to react to exchange rate depreciation with a positive coefficient, but not to credit market indicators. In fact, the optimized coefficient on credit growth is close to zero, even when the central bank considers the objectives of macroeconomic and financial stability as equally desirable. Following a shock that increases the demand for foreign loans (e.g. the perception shocks), a central bank monitoring the credit market tightens the domestic interest rate quite sharply. However, in case of foreign currency borrowing, the relevant opportunity cost of investment is the foreign interest rate, which is taken as given by the small open economy and stays constant. As the monetary policy tightening results in a stronger exchange rate appreciation, it strengthens borrowers' balance sheets, leading to a sharper decrease in leverage and a stronger improvement in balance sheet conditions. Furthermore, the stronger currency appreciation harms competitiveness, leading to a more pronounced fall in export demand which offsets the increase in output driven by the rise in domestic demand. As a result, in pursuing such a monetary policy strategy, the domestic central bank obtains results that conflict with its objectives. First, it does not succeed in smoothing credit developments as the economy is dollarized: on the contrary, it strengthens borrowers' balance sheets. This encourages the build-up of financial vulnerabilities of the kind many Eastern European economies were exposed to before the crisis: overexpansion of foreign currency debt and increase in leverage. Second, it offsets the positive effect of export demand on output, counteracting the expansionary effect of the capital inflow shock. Hence, the central bank can achieve a better result in terms of macroeconomic and financial stabilization if it includes an exchange rate term in the Taylor rule, simultaneously smoothing the volatility of credit aggregates and containing the negative effects of the domestic currency appreciation on exports. These results are robust to the relative magnitude of the capital inflow relative to the technology shock: even when faced when faced with large capital inflow shocks, reacting to credit growth is not optimal. This suggests that a central bank equipped with only one instrument cannot adequately manage capital inflow surges, as a monetary tightening results in a strengthening of borrowers' balance sheets through exchange rate effects and an even higher demand for foreign loans.

Finally, this framework allows to draw interesting insights on the interaction of firm and household leverage in an open economy setting, on the transmission of shocks, and on the role of the monetary policy regime in shaping it. In the case of both technology and capital inflow shocks, the extent of co-movement of financial variables pertaining to entrepreneurs and homeowners crucially depends on whether the exchange rate is flexible or pegged. Specifically, under a fixed exchange rate regime, a negative correlation arises, i.e. stronger balance sheet conditions of entrepreneurs lead to weakened or virtually unchanged balance sheet conditions for homeowners. Under a fixed exchange rate regime, a positive correlation of financial variables of the two types of borrowers arises, mainly operating through the balance sheet effect of exchange rate fluctuations. More specifically, a positive domestic productivity shock exerts opposite effects on capital and housing investment: while housing demand decreases (through a general decline in consumption demand due to lower wage income), capital demand increases because of increased production and external demand. Ceteris paribus, this leads to a fall in homeowners' leverage and a surge in entrepreneurial leverage. While this happens in the case of fixed exchange rate, under a Taylor rule the shock leads to a domestic currency appreciation, which strengthens the balance sheet of borrowers and offsets the opposite effect on investment demand in the two sectors.

In case of capital inflow shocks, similar conclusions can be drawn concerning the interaction between the monetary policy regime and the dynamics of financial variables across sectors. Furthermore, the analysis reveals that sectoral capital inflow shocks spill over to the other sector mainly through their effect on domestic production through increased demand of domestic goods used for investment purposes, and through balance sheet effects of currency appreciation.

The presented analysis can be extended in numerous directions, which will be explored in future research. First and most important, given the results of the optimal monetary policy analysis, a natural avenue for extending the present analysis is to consider the role of macroprudential policies in dealing with foreign capital inflows at the household and entrepreneurial level. To offer a meaningful modeling of macroprudential policy, a financial sector has to be added, which channels foreign funds to investors in the real estate and the production sector. Furthermore, in the presented model, I assumed that all debt is denominated in foreign currency, which is of course an extreme case. Current work is being done in these directions, and on the analysis of the interaction between monetary and macorprudential policy under different degrees of liability dollarization and economic openness. Further research could then be devoted to enriching the international dynamics, examining the international co-movement of asset (including real estate) prices, their consequences on banks' balance sheets and international policy coordination. Extending the model to a two country setting featuring banks engaging in cross-border activities would allow to study issues related to the international transmission of real estate price shocks as well as the effect of policies aimed at regulating the banking sector. Furthermore, this setting would allow to study the interplay between monetary and prudential policies both within a country and from an international cooperation perspective.

4.A Appendix

4.A.1 Derivation of the optimal contract between borrowers and lenders

Here I solve for the optimal credit contract. As entrepreneurs face the same problem as homeowner, in what follows I solve the optimization problem faced by the latter. Analogous first order conditions apply to the entrepreneurial sector. The first order conditions of the optimal contract are obtained by maximizing the expected payoff of homeowners subject to the lenders' participation constraint:

$$\max_{\bar{\omega}^H_{t+1}, H^H_{t+1}} E_t \left[Q_{h,t} H_{t+1} R^h_{t+1} A^H(\bar{\omega}^H_{t+1}) \right]$$

Subject to:

$$Q_{h,t}H_{t+1}^{H}R_{t+1}^{h}B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)=R_{t}(Q_{h,t}H_{t+1}^{H}-NW_{t}^{H})$$

Lagrangian:

$$L=E_{t}\left\{Q_{h,t}H_{t+1}^{H}R_{t+1}^{h}A^{H}(\bar{\omega}_{t+1}^{H})+\vartheta_{t+1}\left[Q_{h,t}H_{t+1}^{H}R_{t+1}^{h}B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)-R_{t}(Q_{h,t}H_{t+1}^{H}-NW_{t}^{H})\right]\right\}$$

Where ϑ_{t+1} is the Lagrange multiplier on the particiation constraint. The first order conditions are:

$$\begin{aligned}
\frac{\partial L}{\partial\bar{\omega}_{t+1}^{H}} &= E_{t}\left\{Q_{h,t}H_{t+1}R_{t+1}^{h}A'^{H}(\bar{\omega}_{t+1}^{H})+\vartheta_{t+1}Q_{h,t}H_{t+1}^{H}R_{t+1}^{h}B'^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)\right\}=0\\
&\Rightarrow E_{t}\left\{Q_{h,t}H_{t+1}R_{t+1}^{h}A'^{H}(\bar{\omega}_{t+1}^{H})\right\}=-E_{t}\left\{\vartheta_{t+1}Q_{h,t}H_{t+1}^{H}R_{t+1}^{h}B'^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)\right\}\\
&\Rightarrow \vartheta_{t+1}=E_{t}\left[-\frac{A'^{H}(\bar{\omega}_{t+1}^{H})}{B'^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)}\right]
\end{aligned}$$

$$\begin{aligned}
\frac{\partial L}{\partial H_{t+1}} &= E_{t}\left\{Q_{h,t}R_{t+1}^{h}A^{H}(\bar{\omega}_{t+1}^{H})+\vartheta_{t+1}Q_{h,t}R_{t+1}^{h}B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)-\vartheta_{t+1}R_{t}Q_{h,t}\right\}=0\\
&\Rightarrow E_{t}\left\{R_{t+1}^{h}\left[B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)-\frac{B'^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)}{A'^{H}(\bar{\omega}_{t+1}^{H})}A^{H}(\bar{\omega}_{t+1}^{H})\right]\right\}=R_{t}\\
&\Rightarrow E_{t}\left\{R_{t+1}^{h}\left[\frac{B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)A'^{H}(\bar{\omega}_{t+1}^{H})-B'^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)A^{H}(\bar{\omega}_{t+1}^{H})}{A'^{H}(\bar{\omega}_{t+1}^{H})}\right]\right\}=R_{t}\\
&\Rightarrow E_{t}\left\{R_{t+1}^{h}\right\}=R_{t}\left(\frac{A'^{H}(\bar{\omega}_{t+1}^{H})}{B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)A'^{H}(\bar{\omega}_{t+1}^{H})-B'^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)A^{H}(\bar{\omega}_{t+1}^{H})}\right)
\end{aligned}$$

$$\frac{\partial L}{\partial\vartheta_{t+1}}=0\Rightarrow Q_{h,t}H_{t+1}^{H}R_{t+1}^{h}B^{H}\left(\bar{\omega}_{t+1}^{H},\upsilon_{t}^{H}\right)=R_{t}(Q_{h,t}H_{t+1}^{H}-NW_{t}^{H})$$

4.A.2 Steady State

In the steady state, I set $S = 1$ and $A = 1$. Furthermore, all relative prices are set to 1, so as all inflation rates: $\frac{P_d}{P^c} = p^d = 1$, $\frac{P_f}{P^c} = p^f = 1$, $\frac{P^h}{P^c} = p^h = 1$, $\pi = \pi^H = \pi^F = 1$. Also the parameters representing lenders' misperception of borrowers' productivity are set to 1 in steady state: $\upsilon^H = \upsilon^E = 1$. The Euler equation implies, together wit the assumption that domestic and foreign interest rates are equal in steady state:

$$R = R^* = \frac{1}{\beta}$$

From which it follows that

$$\Psi = 1$$

Equation (4.23) and its counterpart for housing investment imply that in steady state:

$$Q_k = Q_h = 1$$

The steady state of the credit market is computed assuming target values for three quantities: (1) The risk premium $(R^j - R)$, (2) The leverage ratio of borrowers and (3) the annualized default probability of borrowers $F(\bar{\omega}^j)$ for both entrepreneurs and homeowners. I choose the value of parameters related to monitoring costs in the contract between financial intermediaries and entrepreneurs (μ^E) and between financial intermediaries and homeowners (μ^H), volatility of the idiosyncratic shocks (σ^E, σ^H), steady state threshold productivity levels ($\bar{\omega}^E$, $\bar{\omega}^H$) and the survival rate of entrepreneurs (γ^E) to match the aforementioned steady state quantities.

Given values of σ^E, σ^H and a target value for the default probability in each sector $F(\bar{\omega}^E; \sigma^E)$, $F(\bar{\omega}^H; \sigma^H)$ I can calculate the threshold productivity levels:

$$\bar{\omega}^j = Ncdf^{-1}\left(\frac{\log \bar{\omega}^j + 0.5\sigma_j^2}{\sigma_j}\right)$$

Which I can now use to calculate the quantities $A(\bar{\omega}^j)$, $A^{'}(\bar{\omega}^j)$, $B(\bar{\omega}^j)$ and $B^{'}(\bar{\omega}^j)$.

I can then calculate the steady state external finance premium in both sectors:

$$EFP^j = \frac{A'^j(\bar{\omega}^j)}{B^j\left(\bar{\omega}^j\right)A'^j(\bar{\omega}^j) - B'^j\left(\bar{\omega}^j\right)A^E(\bar{\omega}^j)}$$

From which it follows that

$$\begin{aligned} R^E &= EFP^E \cdot R \\ R^h &= EFP^H \cdot R \end{aligned}$$

Using (4.20) and (4.28) and denoting $lev^H = \frac{Q_h H}{NW^H}$ and $lev^E = \frac{Q_k H}{NW^E}$:

$$\begin{aligned} lev^H &= \frac{1}{1 - B(\bar{\omega}^H)EFP^H} \\ lev^E &= \frac{1}{1 - B(\bar{\omega}^E)EFP^E} \end{aligned}$$

I can now compute the rental rate of capital and the steady state share of housing services, using (4.25) and (4.15):

$$\begin{aligned} r^K &= R^E - (1 - \delta_k) \\ s &= R^h - (1 - \delta_h) \end{aligned}$$

I now turn to the production side of the economy. From **(??)** **(??)** and **(??)** it results that:

$$MC = \frac{\varepsilon - 1}{\varepsilon}$$

Then, using ():

$$\frac{K}{Y} = \frac{MC \cdot \alpha}{r^K}$$

And from the production function:

$$\frac{K}{N} = \left(\frac{K}{Y}\right)^{\frac{1}{(1-\alpha)}}$$

Then using the labor demand equation:

$$W = MC \cdot (1-\alpha)\left(\frac{K}{N}\right)^{\alpha}$$

Fixing total labor supply at $\frac{1}{3}$ of available time, $N = 0.33$ allows to compute[76]:

$$\begin{aligned}
K &= \frac{K}{N} \cdot N \\
Y &= K \cdot \left(\frac{K}{Y}\right)^{-1} \\
F_H &= \frac{MC \cdot Y}{(1-\beta\theta)} \\
D_H &= \frac{Y}{(1-\beta\theta)} \\
\tilde{P}^H &= \frac{\varepsilon}{\varepsilon - 1}\frac{F_H}{D_H} \\
W^E &= MC\,(1-\alpha)\,\Omega_E Y \\
W^H &= MC\,(1-\alpha)\,\Omega_F Y
\end{aligned}$$

Equipped with K, I can solve for investment and the expressions related to entrepreneurial net worth and consumption:

---

[76] Recall that homeowners and entrepreneurs supply one unit of labor inelastically, hence $N^H = N^E = 1$.

$$
\begin{aligned}
NW^E &= \frac{K}{lev^E} \\
V^E &= R^E Q_k K A(\bar{\omega}^E) \\
\tilde{\pi} &= \frac{NW^E - (1-\alpha)\,\Omega^E MC \cdot Y}{V^E} \\
L^E &= Q_k K - NW^E \\
R_L^E &= \frac{\bar{\omega}^E R^E}{1 - \frac{NW^E}{Q_k K}} \\
C^E &= (1-\tilde{\pi})\, R^E Q_k K A(\bar{\omega}^E)
\end{aligned}
$$

Now, fixing the steady state government expenditure at 20% of GDP: $G = 0.2 \cdot Y$, i can use the national accounting identity, and back out the steady state value of the housing stock:

$$
H = \frac{\left(Y - G - \mu^E F\left(\frac{\ln \bar{\omega}^E - 0.5\sigma_E^2}{\sigma_E}\right) \cdot R^E Q_k K - \delta_k K - C^E\right)}{\frac{\gamma_c}{1-\gamma_c} s P^h + \delta_h + \mu^H F\left(\frac{\ln \bar{\omega}^H - 0.5\sigma_H^2}{\sigma_H}\right) \cdot R^h Q_h}
$$

Which I can now use to calculate:

$$
\begin{aligned}
NW^H &= \frac{H}{lev^H} \\
V^H &= R^h Q_h H A(\bar{\omega}^H) \\
D &= V^H + (1-\alpha)\,\Omega^H MC \cdot Y - NW^H \\
\chi_D &= D \cdot lev^H \\
L^H &= Q_h H - NW^H \\
R_L^H &= \frac{\bar{\omega}^H R^h}{1 - \frac{NW^K}{Q_h H}} \\
h &= sH \\
c &= \frac{\gamma_c}{1-\gamma_c} h \left(P^h\right)^{\varsigma} \\
I_h &= \delta_h H
\end{aligned}
$$

I set consumption of Ricardian and non-Ricardian consumers equal in steady state:

$$C^R = C^{NR} = C$$

Then:

$$\begin{aligned} T^{NR} &= D + W \cdot N - C^{NR} \\ T^R &= G - T^{NR} \end{aligned}$$

Now I can solve for the steady state of the labor market:

$$\begin{aligned} \chi_N &= \frac{1}{C} W \cdot N^{-\varphi} \frac{\varepsilon_w - 1}{\varepsilon_w} \\ K^w &= \frac{\varepsilon_w - 1}{\varepsilon_w} W \frac{1}{C} \frac{N}{(1-\beta\theta_w)} \\ F^w &= \frac{\chi_N N^{(1+\varphi)}}{(1-\beta\theta_w)} \end{aligned}$$

Finally, I set the net foreign asset position in steady state equal to zero, meaning a balanced current account in steady state:

$$\begin{aligned} B^* &= 0 \\ X &= c^F + C^E_F + I^F_k + I^F_h \\ Y^* &= \frac{X}{\gamma^*} \end{aligned}$$

4.A.3 Derivations of A($\bar{\omega}$), B($\bar{\omega}$,υ), A'($\bar{\omega}$), B'($\bar{\omega}$,υ)

In order to compute the external finance premia (cfr equations (21) and (22) in the text), I have to compute exact expressions for the quantities $A^j(\bar{\omega}^j_{t+1})$ and $B^j\left(\bar{\omega}^j_{t+1}, \upsilon^j_t\right)$, where $j = H, E$. For notational simplicity, in what follows I will omit the time subscript and the superscript j. Recall:

$$A(\bar{\omega}) = \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega \tag{4.50}$$

$$B\left(\bar{\omega}, \upsilon\right) = \bar{\omega} \int_{\bar{\omega}}^{\infty} f^*(\omega) d\omega^* + (1-\mu) \int_{0}^{\bar{\omega}} \omega^* f^*(\omega) d\omega^* \tag{4.51}$$

The idiosyncratic shock ω is i.i.d., and is assumed to have log-normal distribution with parameters μ and σ_ω: $\omega \sim \log N(\mu, \sigma^2_\omega)$. The density function at $\bar{\omega}$ is:

$$f_\omega(\bar{\omega}) = \frac{1}{\bar{\omega}\sigma_\omega\sqrt{2\pi}} \exp\left\{-\frac{(\ln\bar{\omega}-\mu)^2}{2\sigma^2_\omega}\right\} = \frac{1}{\bar{\omega}\sigma_\omega}\phi\left(\frac{\ln\bar{\omega}-\mu}{\sigma_\omega}\right) \tag{4.52}$$

Where $\phi\left(\cdot\right)$ is the standard normal pdf. The corresponding cumulative distribution function is:

$$\begin{aligned} F_\omega(\bar{\omega};\mu,\sigma_\omega) &= \int_0^{\bar{\omega}} \frac{1}{\omega\sigma_\omega\sqrt{2\pi}} \exp\left\{-\frac{(\ln\omega-\mu)^2}{2\sigma^2_\omega}\right\} d\omega = \\ &= \int_{-\infty}^{\ln\bar{\omega}} \frac{1}{\sigma_\omega\sqrt{2\pi}} \exp\left\{-\frac{(y-\mu)^2}{2\sigma^2_\omega}\right\} dy = \\ &= \int_{-\infty}^{\frac{\ln\bar{\omega}-\mu}{\sigma_\omega}} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}t^2} dt = \Phi\left(\frac{\ln\bar{\omega}-\mu}{\sigma_\omega}\right) \end{aligned} \tag{4.53}$$

Where Φ is the standard normal cdf. The partial expectation is computed as:

$$\begin{aligned}
\int_{\bar\omega}^{\infty}\omega f(\omega)d\omega &= \int_{\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}(\ln\omega-\mu)^2}d\omega = \int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}(y-\mu)^2}e^y dy \\
&= \int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}(y-\mu)^2+y}dy = \int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{y^2+\mu^2-2\mu y-2\sigma_\omega^2 y}{\sigma_\omega^2}\right)}dy = \\
&= \int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}\left(y^2+\mu^2-2y(\mu+\sigma_\omega^2)\right)}dy = \\
&= \int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}\left(y^2+\mu^2-2y(\mu+\sigma_\omega^2)+\sigma_\omega^4+2\mu\sigma_\omega^2-\sigma_\omega^4-2\mu\sigma_\omega^2\right)}dy = \\
&= \int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}(y-(\mu+\sigma_\omega^2))^2+\frac{1}{2}\sigma_\omega^2+\mu}dy = \\
&= \exp\left(\mu+\frac{1}{2}\sigma_\omega^2\right)\int_{\ln\bar\omega}^{\infty}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2\sigma_\omega^2}(y-(\mu+\sigma_\omega^2))^2}dy \\
&= \exp\left(\mu+\frac{1}{2}\sigma_\omega^2\right)\Phi\left(\frac{-\ln\bar\omega+\mu+\sigma_\omega^2}{\sigma_\omega}\right) \qquad (4.54)
\end{aligned}$$

And

$$\int_0^{\bar\omega}\omega f(\omega)d\omega = E\left(\omega|\omega\leq\bar\omega\right)\Pr\left(\omega\leq\bar\omega\right) = \exp\left(\mu+\frac{1}{2}\sigma_\omega^2\right)\Phi\left(\frac{\ln\bar\omega-\mu-\sigma_\omega^2}{\sigma_\omega}\right)$$

In order to derive the necessary expressions for (4.51), recall that lenders have a distorted perception of homeowners' productivity, defined as $\omega^* = \omega\upsilon$ where υ is the misperception factor and $f^*(\omega)$ and $F^*(\omega)$ denote respectively the pdf and cdf of the productivity parameter as perceived by lenders. Hence,

$$\begin{aligned}
F_{\omega^*}(\bar\omega;\mu,\sigma_\omega) &= \Pr\left(\omega^*\leq\bar\omega\right) = \Pr\left(\omega\upsilon\leq\bar\omega\right) = \Pr\left(\omega\leq\frac{\bar\omega}{\upsilon}\right) = \qquad (4.55) \\
&= \int_0^{\frac{\bar\omega}{\upsilon}}\frac{1}{\omega\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\omega-\mu}{\sigma_\omega}\right)^2}d\omega = \\
&= \int_{-\infty}^{\ln\frac{\bar\omega}{\upsilon}}\frac{1}{\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{y-\mu}{\sigma_\omega}\right)^2}dy = \Phi\left(\frac{\ln\frac{\bar\omega}{\upsilon}-\mu}{\sigma_\omega}\right)
\end{aligned}$$

The partial expectation is:

$$\begin{aligned}\int_0^{\bar{\omega}} \omega^* f(\omega^*) d\omega^* &= E\left(\omega^* | \omega^* \leq \bar{\omega}\right) \Pr\left(\omega^* \leq \bar{\omega}\right) = \\ &= E\left(\omega | \omega \leq \frac{\bar{\omega}}{\upsilon}\right) \Pr\left(\omega \leq \frac{\bar{\omega}}{\upsilon}\right) = \\ &= \exp\left(\mu + \ln \upsilon + \frac{1}{2}\sigma_\omega^2\right) \Phi\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} - \mu - \sigma_\omega^2}{\sigma_\omega}\right) \qquad (4.56)\end{aligned}$$

And, plugging (4.53) and (4.54) into (4.50):

$$A(\bar{\omega}) = \exp\left(\mu + \frac{1}{2}\sigma_\omega^2\right) \Phi\left(\frac{-\ln \bar{\omega} + \mu + \sigma_\omega^2}{\sigma_\omega}\right) - \bar{\omega}\left(1 - \Phi\left(\frac{\ln \bar{\omega} - \mu}{\sigma_\omega}\right)\right)$$

Likewise, plugging (4.55) and (4.56) into (4.51):

$$B(\bar{\omega}, \upsilon) = \bar{\omega}\left(1 - \Phi\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} - \mu}{\sigma_\omega}\right)\right) + (1-\mu)\left[\exp\left(\mu + \ln \upsilon + \frac{1}{2}\sigma_\omega^2\right) \Phi\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} - \mu - \sigma_\omega^2}{\sigma_\omega}\right)\right]$$

In the particular case in which $E(\omega) = 1$ so that $\mu = -\frac{\sigma_\omega^2}{2}$ so that $\log \omega \sim N(-\frac{\sigma_\omega^2}{2}, \sigma_\omega^2)$ I obtain:

$$\begin{aligned}A(\bar{\omega}) &= \exp\left(-\frac{\sigma_\omega^2}{2} + \frac{1}{2}\sigma_\omega^2\right) \Phi\left(\frac{-\ln \bar{\omega} - \frac{\sigma_\omega^2}{2} + \sigma_\omega^2}{\sigma_\omega}\right) - \bar{\omega}\left(1 - \Phi\left(\frac{\ln \bar{\omega} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right) = \\ &= 1 - \Phi\left(\frac{\ln \bar{\omega} + \frac{\sigma_\omega^2}{2} - \sigma_\omega^2}{\sigma_\omega}\right) - \bar{\omega}\left(1 - \Phi\left(\frac{\ln \bar{\omega} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right) \qquad (4.57)\end{aligned}$$

$$
\begin{aligned}
B\left(\bar{\omega},\upsilon\right) &= \bar{\omega}\left(1-\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right)+ \\
&+(1-\mu)\left[\exp\left(-\frac{\sigma_\omega^2}{2}+\ln\upsilon+\frac{1}{2}\sigma_\omega^2\right)\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}-\sigma_\omega^2}{\sigma_\omega}\right)\right] \\
B\left(\bar{\omega},\upsilon\right) &= \bar{\omega}\left(1-\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right)+ \qquad (4.58) \\
&+(1-\mu)\cdot\upsilon\cdot\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}-\sigma_\omega^2}{\sigma_\omega}\right)
\end{aligned}
$$

Now I have to compute $A'(\bar{\omega})=\frac{\partial}{\partial\bar{\omega}}A(\bar{\omega})$ and $B'\left(\bar{\omega},\upsilon\right)=\frac{\partial}{\partial\bar{\omega}}B\left(\bar{\omega},\upsilon\right)$. Recall that in general:

$$G(x)=\int_{x_0}^{f(x)}g(t)dt\Rightarrow G'(x)=g(f(x))\cdot f'(x)$$

Furthermore, denoting as $\phi\left(\cdot\right)$ the standard normal pdf, note that:

$$
\begin{aligned}
\frac{1}{\bar{\omega}\sigma_\omega}\phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}-\sigma_\omega^2}{\sigma_\omega}\right) &= \frac{1}{\bar{\omega}\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}-\sigma_\omega^2}{\sigma_\omega}\right)^2} = \\
&= \frac{1}{\bar{\omega}\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\frac{(\ln\bar{\omega})^2+\left(\frac{\sigma_\omega^2}{2}\right)^2+\left(\sigma_\omega^2\right)^2+2(\ln\bar{\omega})\frac{\sigma_\omega^2}{2}-2(\ln\bar{\omega})\sigma_\omega^2-2\frac{\sigma_\omega^2}{2}\sigma_\omega^2}{\sigma_\omega^2}} = \\
&= \frac{1}{\bar{\omega}\sigma_\omega\sqrt{2\pi}}e^{-\frac{\left(\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}\right)^2}{2\sigma_\omega^2}+\ln\omega} = \\
&= \bar{\omega}\cdot\frac{1}{\bar{\omega}\sigma_\omega}\phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) = \\
&= \bar{\omega}\cdot f_\omega\left(\bar{\omega}\right)
\end{aligned}
$$

So that:

$$\begin{aligned}A'(\bar{\omega}) &= -\left[\frac{d}{d\bar{\omega}}\int_0^{\bar{\omega}}\frac{1}{\omega\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\omega+\frac{\sigma_\omega^2}{2}-\sigma_\omega^2}{\sigma_\omega}\right)^2}d\omega\right]-1+\Phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+\\&+\bar{\omega}\cdot\frac{d}{d\bar{\omega}}\int_0^{\bar{\omega}}\frac{1}{\omega\sigma_\omega\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\omega+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}d\omega\end{aligned}$$

$$\begin{aligned}A'(\bar{\omega}) &= -\frac{1}{\bar{\omega}\sigma_\omega}\phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}-\sigma_\omega^2}{\sigma_\omega}\right)-1+\Phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+\\&+\bar{\omega}\left[\frac{1}{\bar{\omega}\sigma_\omega}\phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right]\end{aligned}$$

$$A'(\bar{\omega}) = -1+\Phi\left(\frac{\ln\bar{\omega}+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) \tag{4.59}$$

And

$$\begin{aligned}
B'(\bar{\omega}, \upsilon) &= 1 - \Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) - \bar{\omega}\left[\frac{d}{d\bar{\omega}}\int_0^{\frac{\bar{\omega}}{\upsilon}} \frac{1}{\omega\sigma_\omega\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln\omega + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2} d\omega\right] + \\
&\quad +(1-\mu)\upsilon \cdot \left[\frac{d}{d\bar{\omega}}\int_0^{\frac{\bar{\omega}}{\upsilon}} \frac{1}{\omega\sigma_\omega\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln\omega + \frac{\sigma_\omega^2}{2} - \sigma_\omega^2}{\sigma_\omega}\right)^2} d\omega\right] \\
B'(\bar{\omega}, \upsilon) &= 1 - \Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) - \bar{\omega} \cdot \frac{1}{\frac{\bar{\omega}}{\upsilon}\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2\right] \cdot \frac{1}{\upsilon} + \\
&\quad +(1-\mu) \cdot \upsilon \cdot \frac{1}{\frac{\bar{\omega}}{\upsilon}\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2} - \sigma_\omega^2}{\sigma_\omega}\right)^2\right] \cdot \frac{1}{\upsilon} \\
B'(\bar{\omega}, \upsilon) &= 1 - \Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) - \frac{\bar{\omega}}{\upsilon} \cdot \frac{1}{\frac{\bar{\omega}}{\upsilon}\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2\right] + \\
&\quad +(1-\mu) \cdot \upsilon \cdot \frac{\bar{\omega}}{\upsilon} \cdot \frac{1}{\frac{\bar{\omega}}{\upsilon}\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2\right] \cdot \frac{1}{\upsilon} \\
B'(\bar{\omega}, \upsilon) &= 1 - \Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) - \frac{1}{\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2\right] + \\
&\quad +(1-\mu)\frac{1}{\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2\right] \\
B'(\bar{\omega}, \upsilon) &= 1 - \Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) - \mu\frac{1}{\sigma_\omega\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2\right] \\
B'(\bar{\omega}, \upsilon) &= 1 - \Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) - \frac{\mu}{\sigma_\omega}\phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right) + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)
\end{aligned}$$

Now I calculate the second derivatives $A''(\bar{\omega}) = \frac{\partial}{\partial\bar{\omega}}A'(\bar{\omega})$ and $B''(\bar{\omega}, \upsilon) = \frac{\partial}{\partial\bar{\omega}}B'(\bar{\omega}, \upsilon)$:

$$A''(\bar{\omega}) = \frac{d}{d\bar{\omega}} \int_0^{\bar{\omega}} \frac{1}{\omega \sigma_\omega \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \omega + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2} d\omega = \frac{1}{\bar{\omega}\sigma_\omega} \phi\left(\frac{\ln \bar{\omega} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)$$

$$B''(\bar{\omega}, \upsilon) = -\frac{d}{d\bar{\omega}} \int_0^{\frac{\bar{\omega}}{\upsilon}} \frac{1}{\omega \sigma_\omega \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \omega + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2} d\omega - \frac{\mu}{\sigma_\omega} \cdot \frac{d}{d\bar{\omega}} \left(\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\right) =$$

$$B''(\bar{\omega}, \upsilon) = \left\{ \begin{array}{c} -\left[\frac{1}{\frac{\bar{\omega}}{\upsilon}\sigma_\omega\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\right] \cdot \\ \frac{1}{\upsilon} - \frac{\mu}{\sigma_\omega}\left(\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2} \cdot \left(-\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\left(\frac{1}{\sigma_\omega}\frac{1}{\frac{\bar{\omega}}{\upsilon}}\frac{1}{\upsilon}\right)\right) \end{array} \right\} =$$

$$B''(\bar{\omega}, \upsilon) = \left\{ \begin{array}{c} -\left[\frac{1}{\bar{\omega}\sigma_\omega\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\right] + \\ \frac{\mu}{\sigma_\omega}\left(\frac{1}{\bar{\omega}\sigma_\omega\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2} \cdot \left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right) \end{array} \right\} =$$

$$B''(\bar{\omega}, \upsilon) = -\frac{1}{\bar{\omega}\sigma_\omega} \phi\left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\left[1 - \mu \cdot \left(\frac{\ln \frac{\bar{\omega}}{\upsilon} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega^2}\right)\right]$$

For the log-linearized model, I need the following derivatives: $\frac{d}{d\upsilon}B\left(\bar{\omega},\upsilon\right)$ and $\frac{d}{d\upsilon}B'\left(\bar{\omega},\upsilon\right)$

$$\begin{aligned}
\frac{d}{d\upsilon}B\left(\bar{\omega},\upsilon\right) &= \frac{d}{d\upsilon}\left[\bar{\omega}\left(1-\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right)+(1-\mu)\cdot\upsilon\cdot\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right] \\
\frac{d}{d\upsilon}B\left(\bar{\omega},\upsilon\right) &= -\bar{\omega}\cdot\left\{\frac{d}{d\upsilon}\left[\int_{-\infty}^{\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}t^2}dt\right]\right\}+(1-\mu)\cdot\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+ \\
&\quad +(1-\mu)\cdot\upsilon\cdot\left\{\frac{d}{d\upsilon}\left[\int_{-\infty}^{\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}t^2}dt\right]\right\} \\
\frac{d}{d\upsilon}B\left(\bar{\omega},\upsilon\right) &= -\bar{\omega}\cdot\left[\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\cdot\left(-\frac{1}{\sigma_\omega}\frac{\upsilon}{\bar{\omega}}\frac{\bar{\omega}}{\upsilon^2}\right)\right]+ \\
&\quad +(1-\mu)\cdot\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+ \\
&\quad +(1-\mu)\cdot\upsilon\cdot\left[\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\cdot\left(-\frac{1}{\sigma_\omega}\frac{\upsilon}{\bar{\omega}}\frac{\bar{\omega}}{\upsilon^2}\right)\right] \\
\frac{d}{d\upsilon}B\left(\bar{\omega},\upsilon\right) &= \frac{\bar{\omega}}{\upsilon\sigma_\omega}\cdot\phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+(1-\mu)\cdot\Phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+ \\
&\quad -(1-\mu)\cdot\frac{1}{\sigma_\omega}\cdot\phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)-\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)
\end{aligned}$$

$$\frac{d}{d\upsilon}B'\left(\bar{\omega},\upsilon\right) = \left\{\begin{array}{c} -\frac{d}{d\upsilon}\left[\int_{-\infty}^{\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}t^2}dt\right]+ \\ -\frac{\mu}{\sigma_\omega}\cdot\frac{d}{d\upsilon}\left[\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\right]\end{array}\right\} =$$

$$\begin{aligned}\frac{d}{d\upsilon}B'\left(\bar{\omega},\upsilon\right) &= \left[\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\cdot\left(\frac{1}{\sigma_\omega}\frac{\upsilon}{\bar{\omega}}\frac{\bar{\omega}}{\upsilon^2}\right)\right]+ \\ &\quad -\frac{\mu}{\sigma_\omega}\left[\begin{array}{c}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)^2}\cdot\left(-\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right) \\ \cdot\left(-\frac{1}{\sigma_\omega}\cdot\frac{1}{\frac{\bar{\omega}}{\upsilon}}\frac{\bar{\omega}}{\upsilon^2}\right)\end{array}\right] \\ \frac{d}{d\upsilon}B'\left(\bar{\omega},\upsilon\right) &= \left\{\begin{array}{c}\frac{1}{\upsilon\sigma_\omega}\cdot\phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)+ \\ -\frac{\mu}{\upsilon\sigma_\omega}\left[\phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\left(\frac{1}{\sigma_\omega}\right)\right]\end{array}\right\} \\ \frac{d}{d\upsilon}B'\left(\bar{\omega},\upsilon\right) &= \frac{1}{\upsilon\sigma_\omega}\cdot\phi\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\cdot\left[1-\frac{\mu}{\sigma_\omega}\left(\frac{\ln\left(\frac{\bar{\omega}}{\upsilon}\right)+\frac{\sigma_\omega^2}{2}}{\sigma_\omega}\right)\right]\end{aligned}$$

4.A.4 Extension of the model to different currency denomination of borrowing

The baseline specification of the model implies that borrowing in the small open economy is contracted with foreign lenders only and that it is entirely denominated in foreign currency. Before proceeding, it is important to stress the difference between the nationality of lenders (domestic vs foreign) and the currency denomination of loans (domestic vs foreign). The nationality of lenders is key in defining the participation constraint of lenders in the financial contract, and the external finance premium resulting from the optimal contract. In fact, while the relevant opportunity cost for domestic lenders is the domestic interest rate, that of foreign lenders is the foreign interest rate. This implies that, in case of domestic borrowing, the external finance premium facing borrowers will depend on the domestic risk-free rate, while in case of foreign borrowing it will depend on the foreign risk-free rate. On the other hand, the currency denomination of loans influences the balance sheet of borrowers, and the external finance premium through leverage effects. It is important to notice that the currency denomination of the loan can be disentangled from the residence of the lender: in fact, we can have loans in foreign currency granted by domestic lenders and loans in domestic currency granted from foreign lenders. When borrowers contract loans in foreign currency, an exchange rate depreciation raises the domestic currency value of debt and increases borrowers' leverage, even if the loan is granted by domestic lenders (and thence the external finance premium will be related to the domestic interest rate).

Having said that, different degrees of financial dollarization can be introduced in two ways, each of them characterized by strenghts and drawbacks.

First, we can assume that a fraction of borrowers (say $(1-\xi)$) borrows from domestic lenders (in domestic currency) and the remaining fraction (ξ) borrows from foreign lenders (in foreign currency). This modeling strategy has already been adopted in the literature, for example in studies by Unsal (2011) and Saxegaard et al (2010), and it is theoretically sound. However, it raises some concerns on the grounds of practical implementation in the context of the present study. This framework implies that the external finance premium of borrowers receiving loans from domestic lenders depends on the domestic risk-free rate, while for borrowers contracting loans with foreign lenders the external finance premium would depend on the foreign risk-free rate. For practical purposes, imagine that each group of borrowers stipulates a contract with lenders: $(1 - \xi)$ borrowers stipulate a contract with domestic lenders, while ξ borrowers do so with foreign lenders. In this setting, only borrowers receiving loans from foreign lenders would be affected by the capital inflow (i.e. perception shock), because the remaining fraction of borrowers are receiving funds from domestic financial intermediaries. Therefore, this modeling framework implies that as $\xi \to 0$ not only the degree of financial dollarization desappears, but also the capital inflow shock. This problem could be mitigated by calibrating the perception shock such that the magnitude of the capital inflow induced by the shock is the same for different values of ξ (for example by calibrating it so that the initial impact on capital inflows to GDP is of the same magnitude across values of ξ). However, this will have important implications for the optimal monetary policy analysis. In fact, the optimized Taylor rule coefficients are calculated assuming the economy is hit by all shocks at the same time. The optimized Taylor rules for different central bank's loss functions will still be comparable, but only for given ξ. In fact, as the degree of foreign borrowing decreases, the capital inflow (perception) shock will have less and less impact on the economy: even if the magnitude of the shock won't change, its impact on the economy will decrease with ξ. This makes two optimized policy rules obtained for a given assumed loss function, but different values of ξ, hardly comparable. Furthermore, this framework does not allow to disentangle liability dollarization from origin of loans (domestic or foreign). In fact, this setting implies that a degree of sensitivity of borrowers to the domestic interest rate is introduced, while it was not present in the original model specification. This would shift the focus of the paper on the difference between domestic and foreign borrowing rather than domestic vs foreign *currency* borrowing. This will also have implications for the optimal monetary policy results. In fact, in this case a contractionary monetary policy action in response to a capital inflow shock will exert opposite results on borrowers' balance sheets according to the origin of loans they are contracting. On one side, the resulting currency appreciation will decrease the debt burden of those borrowing from foreign lenders; on the other side, it will increse the external finance premium of those borrowing domestically.

Second, we can still assume that loans come exclusively from foreign lenders, but that a fraction of them ($(1-\xi)$) is in domestic currency while the remaining fraction (ξ) is in foreign currency. In this case, the external finance premium would still depend entirely on the foreign risk-free rate (which is the relevant opportunity cost for lenders) for all borrowers, but the degree of financial dollarization will affect the net worth only of borrowers receiving loans in foreign currency. A lower value of ξ (i.e. lower financial dollarization) implies that changes in the exchange rate have a lower impact on borrowers' leverage, which means that a domestic monetary policy contraction which leads to exchange rate appreciation will have a smaller acceleration effect. This modeling framework is appealing because it allows to isolate the effect of currency denomination of borrowing from the country origin of loans. Furthermore, in this setup, the perception shock will not desappear as $\xi \to 0$, because all borrowers are borrowing from foreign lenders and are then affectd by the capital inflow shock. As $\xi \to 0$, the fraction of borrowers borrowing in foreign currency shrinks, which reduces the overall balance sheet effect of currency fluctuations as domestic currency borrowers become predominant. However, from a theoretical perspective, this modelling framework poses two challenges. First, there is the issue of who is bearing the exchange rate risk: borrowers or foreign lenders? Foreign lenders are lending in different currencies, so their portfolio of assets will be affected by currency fluctuations, and they risk to incur losses when the currency of the small open economy appreciates (because they will receive less when they convert loans repayments in the small economy's currency to the foreign currency). We can assume that foreign lenders transfer this burden to borrowers, implying that the external finance premium they charge to domestic currency borrowers will be adjusted by exchange rate appreciation. However, this implies that even domestic currency borrowers' borrowing conditions will be affected by currency fluecutations, which detriments our intent to isolate the effect of currency denomination of loans. The second challenge comes from the balance of payments. In fact, as borrowers receiving domestic currency are borrowing from foreign lenders, loans received from abroad should be classified as capital inflows and included in the balance of payments equation. However, they are denominated in domestic currency, which means that if they were to be accounted in the balance of payments (in foreign currency), there should somewhere be an adjustment for currency fluctuations.

Hence, the choice is not simple. While the first method is correct from a modeling perspective but lacks practical applicability for the purposes of this paper, the second framework fits the purposes of the paper but has some theoretical shortcomings. Therefore, I decide not to include any of these modifications in the final thesis. However, here I provide the results I obtain by applying the second method, i.e. the one that at leas allows isolating the effect of liability dollarization and allows for comparability of the resulting optimal policy rules. Here below I describe how I model the contract between entrepreneurs and banks, as the setup is similar for homeowners.

Entrepreneurs finance capital investments borrowing from foreign lenders. Let us assume that the continuum of entrepreneurs is composed of two groups: a fraction of them $(1-\xi)$ borrows in domestic currency while the remaining fraction (ξ) borrows in foreign currency. Specifically, the entrepreneurial sector as a whome has net worth $NW^E_{t+1}$and uses a fraction $(1-\xi)$ to finance an expenditure $(1-\xi)Q_t K^{ED}_{t+1}$ with loans in domestic currency, and a fraction ξ to finance an expenditure $\xi Q_t K^{EF}_{t+1}$ with loans in foreign currency[77]. Therefore, loans of each type of entrepreneurs (in domestic currency) are given by:

$$
\begin{aligned}
L^{ED}_{t+1} &= (1-\xi)(Q_t K^{ED}_{t+1} - NW^H_{t+1}) &\quad (4.60)\\
S_t L^{EF}_{t+1} &= \xi(Q_t K^{EF}_{t+1} - NW^H_{t+1}) &\quad (4.61)
\end{aligned}
$$

I assume that each entrepreneur is subject to an idiosyncratic technology shock $\omega^{Ej}_{t+1}(i) \sim \log N(-\frac{\sigma^2_E}{2}, \sigma^2_E)$, $j = D, F$, the realization of which determines the profitability of their investment and, then, their default probability. The threshold productivity level that discriminates between defaulting and non-defaulting entrepreneurs is given, for each type, by:

$$
\begin{aligned}
\bar{\omega}^{ED}_{t+1}(i) Q_t K^{ED}_{t+1}(i) R^{ED}_{t+1} &= R^{ED}_{L,t+1} L^{ED}_{t+1}(i) = R^{ED}_{L,t+1}(Q_t K^{ED}_{t+1}(i) - NW^E_{t+1}(i)) &\quad (4.62)\\
\bar{\omega}^{EF}_{t+1}(i) \frac{Q_t K^{EF}_{t+1}(i) R^{EF}_{t+1}}{S_{t+1}} &= R^{EF}_{L,t+1} L^{EF}_{t+1}(i) = R^{EF}_{L,t+1} \frac{(Q_t K^{EF}_{t+1}(i) - NW^E_{t+1}(i))}{S_t} &\quad (4.63)
\end{aligned}
$$

Where R^{ED}_{t+1} and R^{EF}_{t+1} is the return from capital investment for each type of entrepreneur, composed of the return to capital and the capital gain[78]:

$$
R^{ED}_{t+1} = R^{EF}_{t+1} = \frac{r^K_{t+1} + (1-\delta_k)\, Q_{k,t+1}}{Q_{k,t}} \quad (4.64)
$$

[77] Here I denote with a superscript ED (EF) variables pertaining to entrepreneurs borrowing in domestic (foreign) currency.

Note also that capital (K) is homogeneous in the economy. The distinction between K^{ED} and K^{EF} is made only for notational convenience.

[78] As capital is homogeneous, returns are equal.

Each type of entrepreneur stipulates a financeal contract with the foreign lender. The expected payoff of entrepreneurs from the financial contract is given by:

$$E_t \left\{ (1-\xi) \cdot \left[\begin{array}{c} Q_t K_{t+1}^{ED}(i) R_{t+1}^{ED} \left(\int_{\bar{\omega}_{t+1}^{ED}}^{\infty} \omega_{t+1}^{ED} f\left(\omega_{t+1}^{ED}\right) d\omega_{t+1}^{ED} \right) + \\ -\left(\int_0^{\bar{\omega}_{t+1}^{ED}} f\left(\omega_{t+1}^{ED}\right) d\omega_{t+1}^{ED} \right) R_{L,t+1}^{ED} L_{t+1}^{ED} \end{array} \right] \right\} = \\ = E_t \left\{ (1-\xi) \left[Q_t K_{t+1}^{ED}(i) R_{t+1}^{ED} \cdot A(\bar{\omega}_{t+1}^{ED}) \right] \right\} \tag{65}$$

$$E_t \left\{ \xi \cdot \left[\begin{array}{c} Q_t K_{t+1}^{EF} R_{t+1}^{EF} \left(\int_{\bar{\omega}_{t+1}^{EF}}^{\infty} \omega_{t+1}^{EF} f\left(\omega_{t+1}^{EF}\right) d\omega_{t+1}^{EF} \right) + \\ -\left(\int_0^{\bar{\omega}_{t+1}^{EF}} f\left(\omega_{t+1}^{EF}\right) d\omega_{t+1}^{EF} \right) R_{L,t+1}^{EF} L_{t+1}^{EF} \end{array} \right] \right\} = \\ = E_t \left\{ \xi \cdot \left[Q_t K_{t+1}^{EF} R_{t+1}^{EF} \cdot A(\bar{\omega}_{t+1}^{EF}) \right] \right\} \tag{66}$$

The participation constraint of the foreign lender in the contract with each type of entrepreneur is:

$$E_t \left\{ (1-\xi) \left[Q_t K_{t+1}^{ED} R_{t+1}^{ED} \cdot B(\bar{\omega}_{t+1}^{ED}, \upsilon_t^E) \right] \right\} \leq R_t^* (1-\xi) \left(Q_t K_{t+1}^{ED} - NW_{t+1}^{E} \right) \tag{67}$$

$$E_t \left\{ \xi \left[\frac{Q_t K_{t+1}^{EF} R_{t+1}^{EF}}{S_{t+1}} \cdot B(\bar{\omega}_{t+1}^{EF}, \upsilon_t^E) \right] \right\} \leq R_t^* \xi \frac{\left(Q_t K_{t+1}^{EF} - NW_{t+1}^{F} \right)}{S_t} \tag{68}$$

Where $B^{Ej}\left(\bar{\omega}_{t+1}^{Ej}, \upsilon_t^E\right) = \left[\left(\int_{\bar{\omega}_{t+1}^{Ej}(i)}^{\infty} f(\omega^{Ej*}) d\omega^{Ej*} \right) + (1-\mu^E) \left(\int_0^{\bar{\omega}_{t+1}^{Ej}(i)} \omega_{t+1}^{Ej*} f(\omega^{Ej*}) d\omega^{Ej*} \right) \right]$

Recall that, as in the original specification, lenders have a distorted perception of entrepreneurial productivity, given by $\omega_{t+1}^{Ej*} = \omega_{t+1}^{Ej} \upsilon_t^E$ where $\upsilon_t^E \in [0,1]$ is the misperception factor which evolves according to $\ln(\upsilon_t^E) = \rho_\upsilon \ln(\upsilon_{t-1}^E) + \xi_\upsilon^E$. I assume that the misperception factor υ_t^E is the same for both types of entrepreneurs, as they are homogeneous in the eyes of the foreign lender.

The first order conditions of the financial contract for domestic currency borrowers are given by:

$$E_t\left(R_{t+1}^{EF}\right) = R_{t+1}^{*}\left[\frac{A'^{EF}(\bar{\omega}_{t+1}^{EF})}{B^{EF}\left(\bar{\omega}_{t+1}^{EF},\upsilon_t^{E}\right)A'^{EF}(\bar{\omega}_{t+1}^{EF}) - B'^{EF}\left(\bar{\omega}_{t+1}^{EF},\upsilon_t^{E}\right)A^{EF}(\bar{\omega}_{t+1}^{EF})}E_t\left\{\frac{S_{t+1}}{S_t}\right\}\right] \tag{69}$$

$$\left\{(1-\xi)\left[Q_t K_{t+1}^{ED} R_{t+1}^{ED}\cdot B(\bar{\omega}_{t+1}^{ED},\upsilon_t^{E})\right]\right\} \leq R_t^{*}(1-\xi)\left(Q_t K_{t+1}^{ED} - NW_{t+1}^{E}\right) \tag{70}$$

The first order conditions of the financial contract for foreign currency borrowers are given by:

$$E_t\left(R_{t+1}^{ED}\right) = R_{t+1}^{*}\left[\frac{A'^{ED}(\bar{\omega}_{t+1}^{ED})}{B^{ED}\left(\bar{\omega}_{t+1}^{ED},\upsilon_t^{E}\right)A'^{ED}(\bar{\omega}_{t+1}^{ED}) - B'^{ED}\left(\bar{\omega}_{t+1}^{ED},\upsilon_t^{E}\right)A^{ED}(\bar{\omega}_{t+1}^{ED})}\right] \tag{71}$$

$$E_t\left\{\xi\left[Q_t K_{t+1}^{EF} R_{t+1}^{EF}\cdot B(\bar{\omega}_{t+1}^{EF},\upsilon_t^{E})\right]\right\} \leq R_t^{*}\xi\left(Q_t K_{t+1}^{EF} - NW_{t+1}^{E}\right) \tag{72}$$

Net worth accumulates according to the following equation:

$$NW_{t+1}^{E} = \varrho\left\{(1-\xi)\cdot A^{ED}(\bar{\omega}_t^{ED})R_t^{ED}Q_{t-1}K_t^{ED} + \xi\cdot A^{EF}(\bar{\omega}_t^{EF})R_t^{EF}Q_{t-1}K_t^{EF}\right\} + W_t^{E} \tag{4.73}$$

Finally, total capital in the economy is equal to:

$$K_{t+1} = (1-\xi)K_{t+1}^{ED} + \xi K_{t+1}^{EF} \tag{4.74}$$

Figures 4.10 to 4.13 depict the response of the main model variables to a one standard deviation technology shock, for different degrees of financial dollarization and specifications of the cental bank's monetary policy rule.

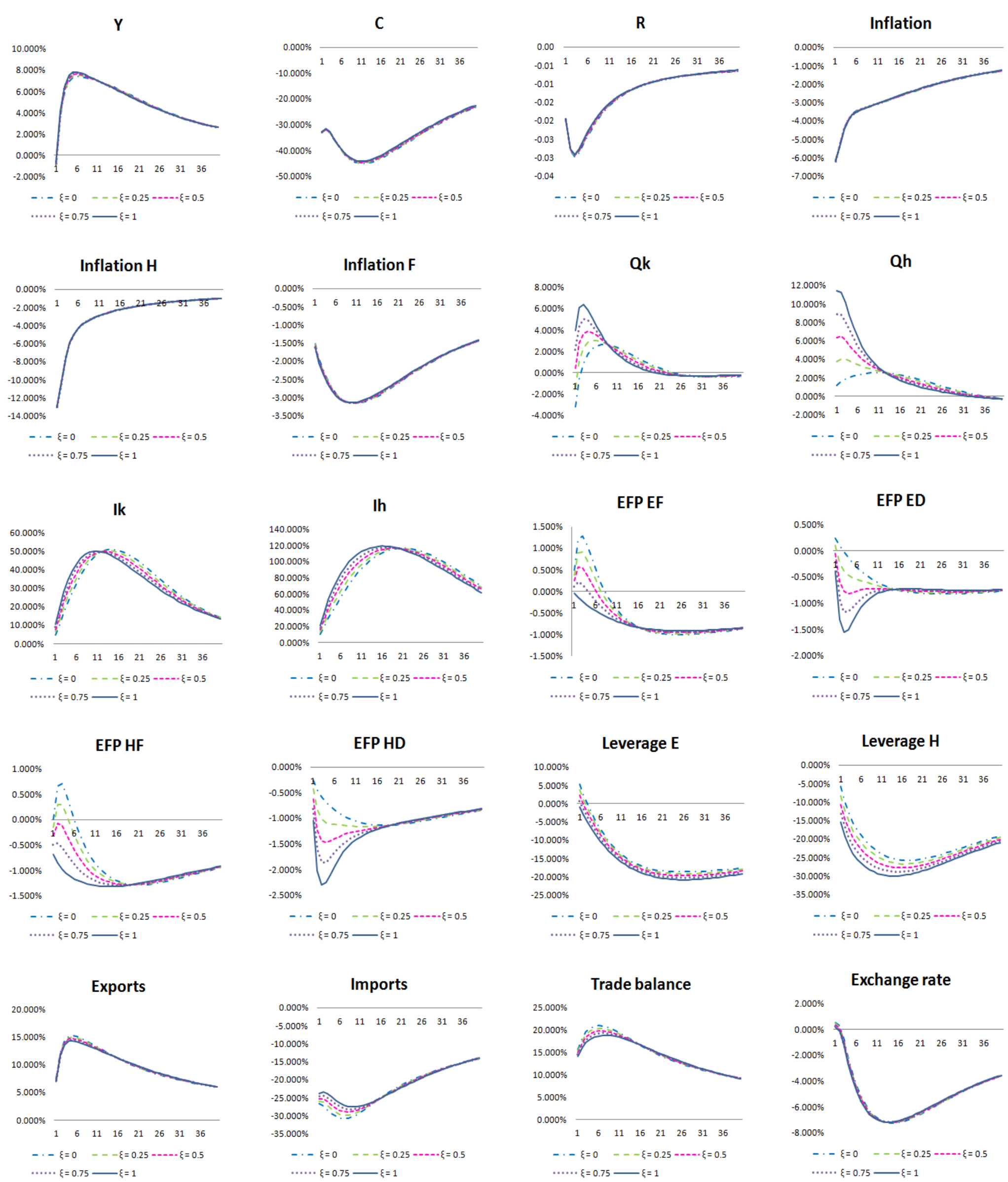
As in the baseline case, the technology shock reduces marginal costs and the price of domestically produced goods, leading to a decrease in firms' demand for labor and hence a fall in wages, which in turn dampens the demand for consumption goods and housing services. However, as domestic inflation decreases, external demand surges, which compensates the fall in domestic demand, encourages production and firms' demand for capital goods. As a consequence, entrepreneurs engage in more investment projects, pushing up the price of capital and the demand for credit. As exports increase and imports decrease, the trade balance switches into surplus and the exchange rate appreciates. From these figures, it emerges that the share of foreign currency borrowing mainly affects variables related to entrepreneurs and homeowners, but it has a negligible repercussions on variables such as output, inflation and the interest rate. Specifically, we can observe differences in the responses of leverage, external finance premia, asset prices and, in smaller magnitude, investment, which are mainly given by the different balance sheet effect of currency movements as the degree of financial dollarization changes.

As the exchange rate appreciates, borrowers receiving loans in foreign currency see the domestic currency value of their loan burden decrease, and their balance sheet position becoming stronger. In fact, leverage and the external finance premium decrease and the fall is more pronounced the greater the degree of liability dollarization. Furthermore, entrepreneurs receiving loans in domestic currency benefit from positive spillovers of the increase in the price of capital and the increase in net worth in the sector. In fact, as the price of capital and net worth increase, their leverage decreases, leading them to enjoy more favorable borrowing conditions. In the limit case when the degree of foreign currency borrowing is zero, the relevant line to look at is the dashed-dotted blue line. In this case, only domestic currency borrowers exist. Since they no longer benefit from the reduction of the loan burden deriving from the currency appreciation, the initial effect of their increased demand for credit results in an increase in the external finance premium on impact (cfr graph EFP ED) and a decrease in the asset price. However, as the return to capital is high, they start investing and, by doing so, they push up the price of capital and the external finance premium down. A simila reasoning holds for homeowners. As the demand for housing decreases as a consequence of the technology shock, homeowners demand less credit and they push down the external finance premium. This decrease is magnified the higher the degree of financial dollarization, due to the additional balance sheet effect of currency appreciation. As financing conditions improve, homeowners demand more credit and start investing in new housing projects, which pushes up the price of unfinished houses. However, the asset price decreases much less when the degree of financial dollarization is zero.

However, overall, the effect of these developments on output is limited. It can be noticed that output increase slightly more in the case of full liability dollarization, but the difference is not significant.

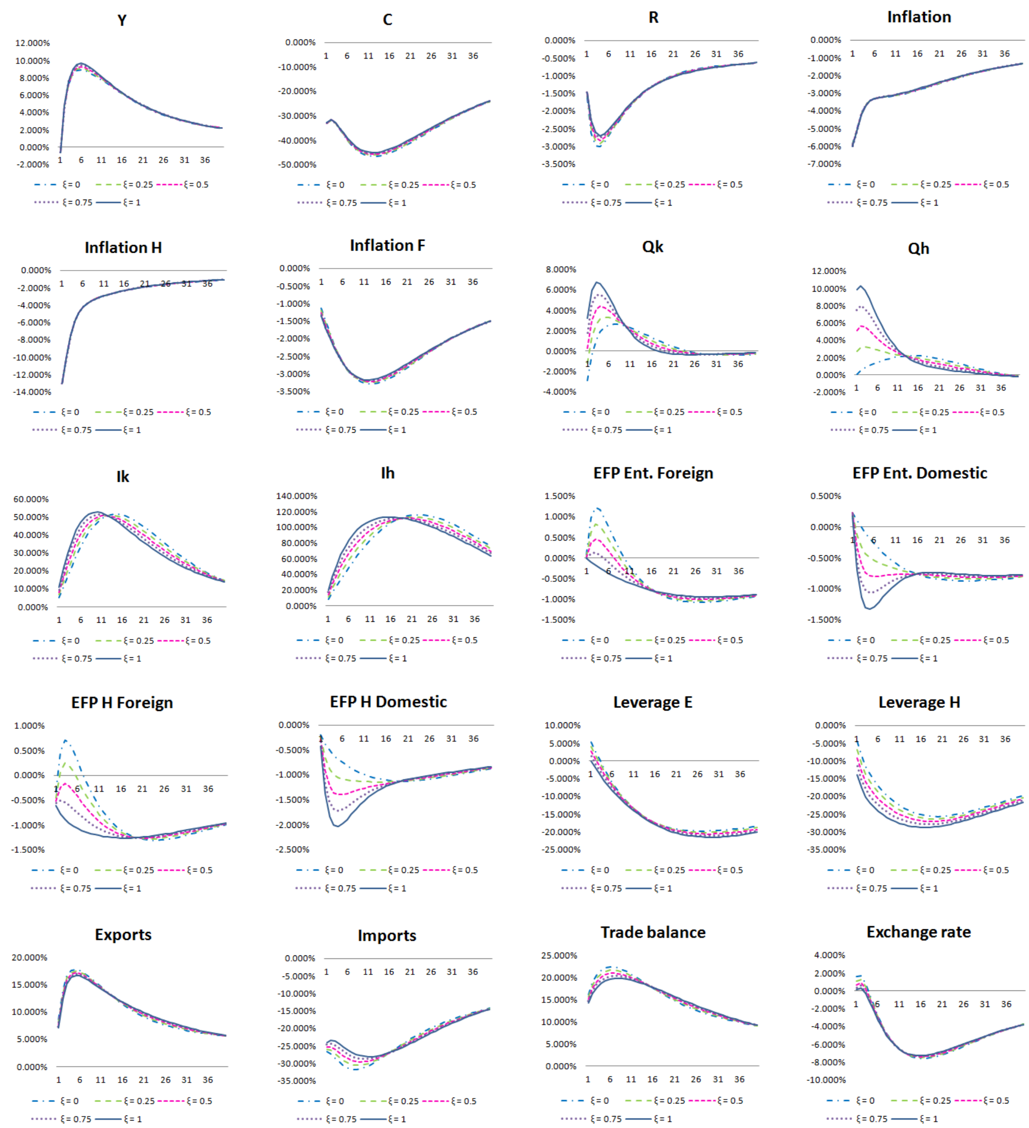
Turning now to the comparison of the responses across monetary policy rules, we can see that the effect of changing the degree of liability dollarization is broadly similar. Financial conditions significantly improve the stronger the share of foreign currency borrowing, but the effects on output, inflation and the interest rate are small. Only in the case of Talylor rule augmented with loan growth the effect on the interest rate differs across degrees of liability dollarization. As the central bank reacts to the domestic currency value of loans, the lower the degree of foreign currency borrowing the stronger the decrease in the interest rate. As it can be expected, in the case of fixed exchange rate, there are no difference across degrees of liability dollarization.

Figure 4.10: Responses to a domestic technology shock under standard Taylor rule and different shares of foreign currency borrowing



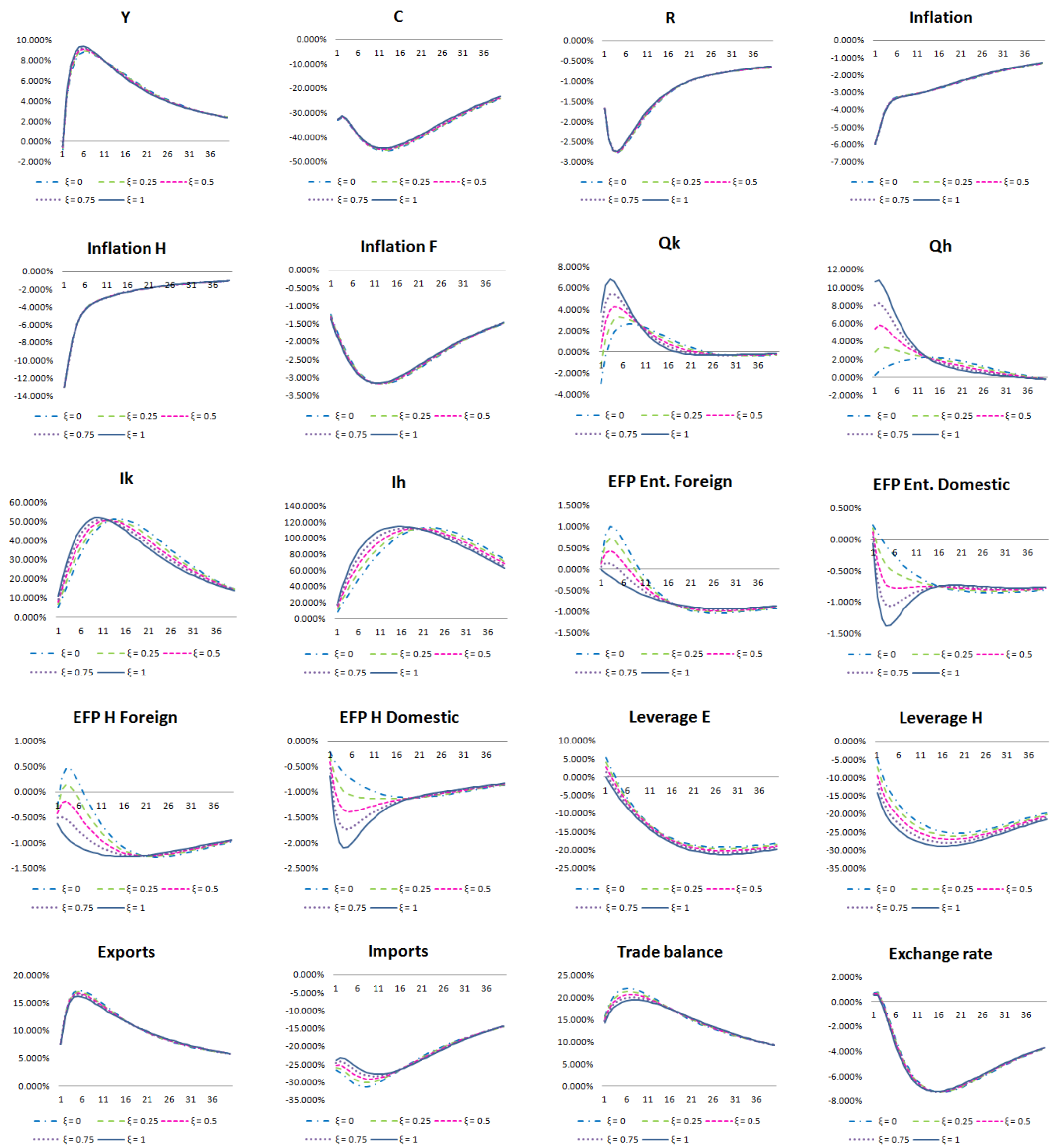
Note: Responses to a one standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.11: Responses to a technology under Taylor rule + Loan growth and different shares of foreign currency borrowing



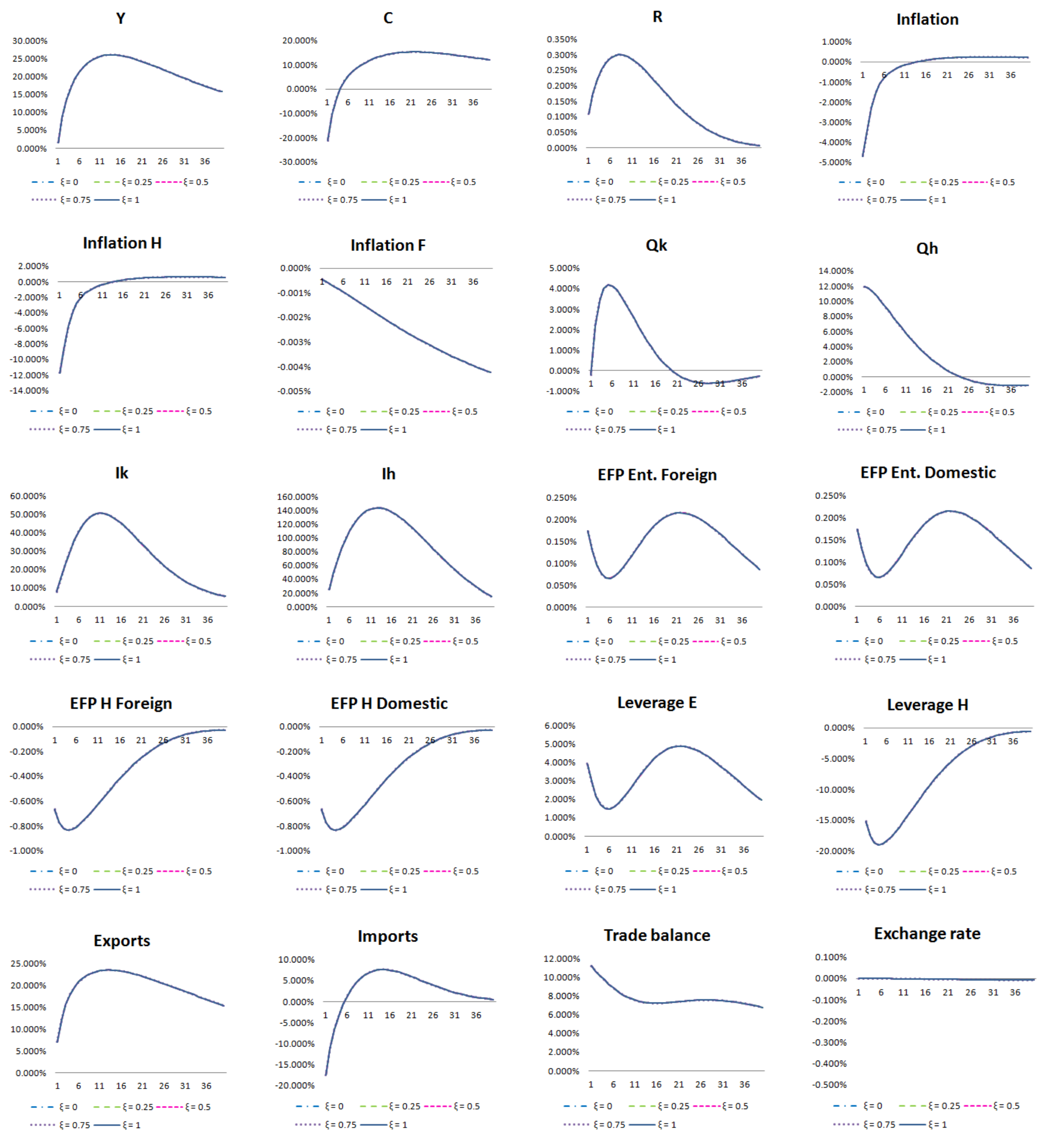
Note: Responses to a 1 standard deviations technology shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.12: Responses to a technology shock under Taylor rule + Exchange rate and different shares of foreign currency borrowing



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.13: Responses to a technology shock under Fixed exchange rate regime and different shares of foreign currency borrowing



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

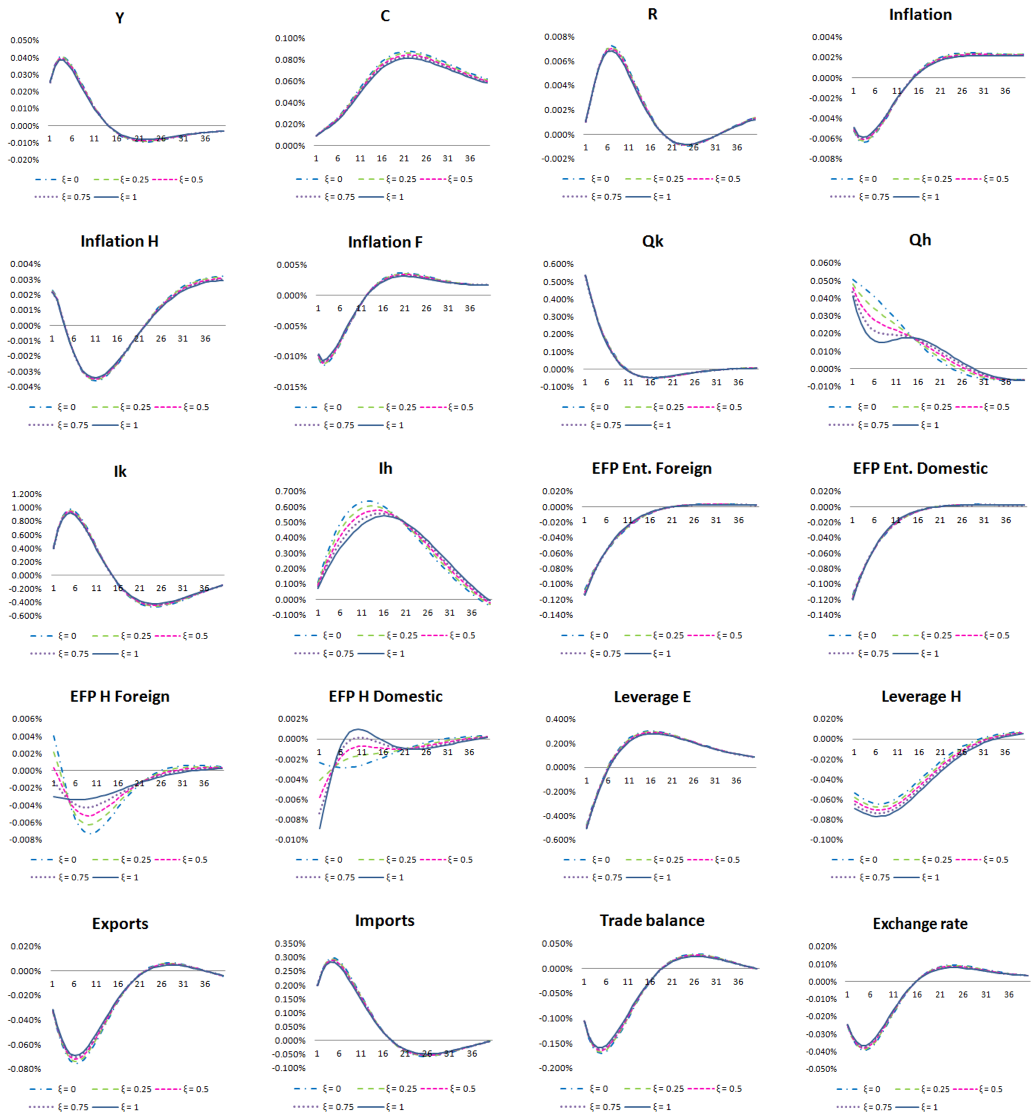
Figures 4.14 to 4.17 depict the impulse-response functions to a 0.01 capital inflow shock to the entrepreneurial sector, for different degrees of liability dollarization and monetary policy rules.

Once again, different degrees of foreign currency borrowing mainly affect financial variables, and this time the difference is magnified for homeowners. Specifically, as entrepreneurs are the ones subject to the shock, which impacts their borrowing conditions directly, the responses do not vary for different values of ξ.

As the capital inflow shock hits, entrepreneurs' borrowing conditions improve, so they undertake more investment projects, the asset price increase and the rental price of capital for firms decrease, which leads them to purchase more, thereby increasing production. The positive capital inflow puts appreciating pressures on the currency, which has a beneficial effect on balance sheets of homeowners borrowing in foreign currency. In fact, the greater the degree of financial dollarization, the more the external finance premium for homeowners decreases on impact.

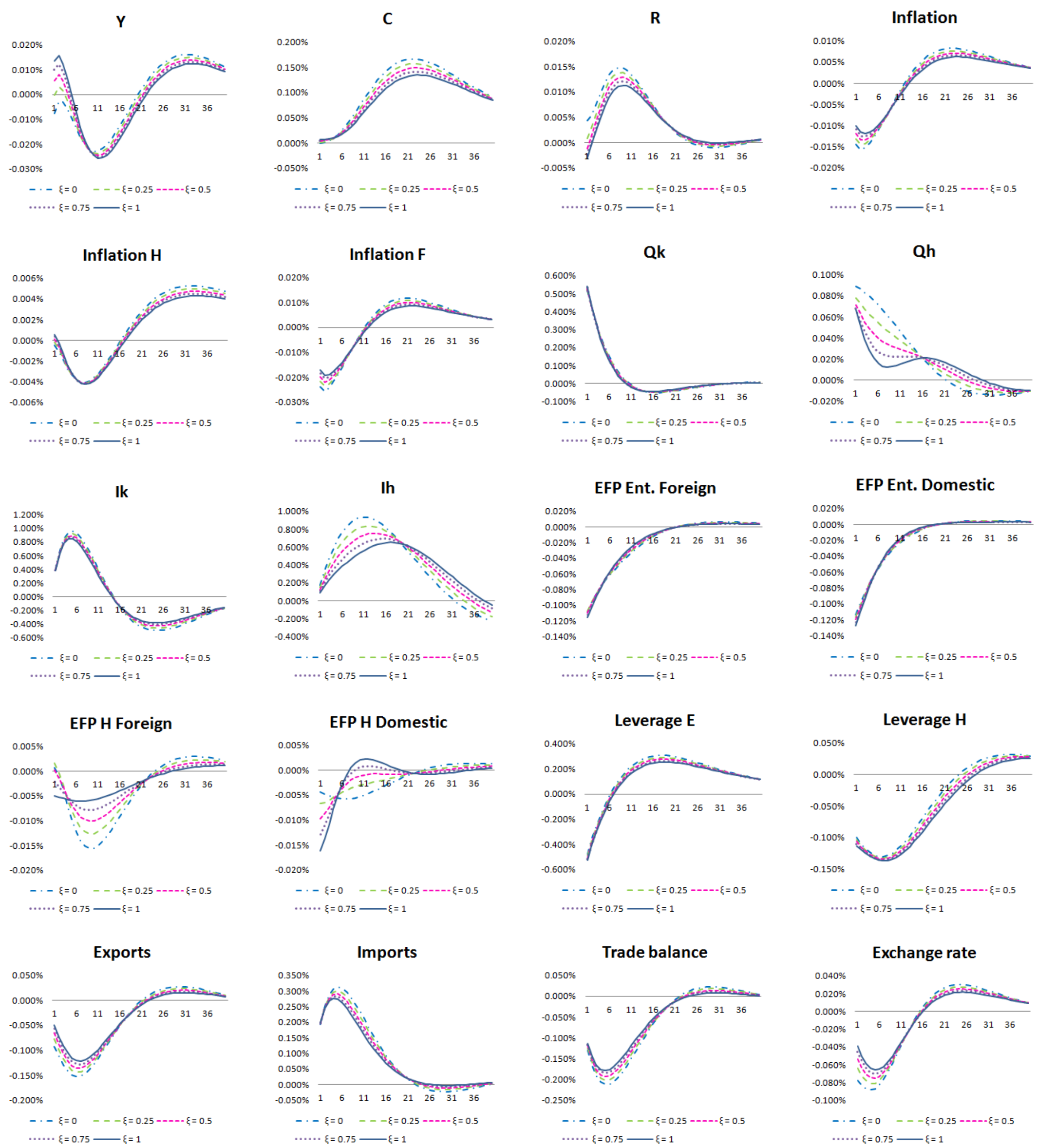
In case the central bank sets the interest rate according to a Taylor rule augmented with loans growth (cfr figure 4.15), the differences in the impact of the shock across digree of financial dollarization on output, inflation and the interest rate are more marked. Specifically, the lower the degree of financial dollarization, the smaller is the effect of the exchange rate appreciation of the domestic currency value of loans. Therefore, loans (in domestic currency) are greater in case of low liability dollarization: as the central bank reacts to loans growth, the magnitude of the interest rate increase is greater the lower the share of foreign currency borrowing. The larger interest rate hike in this case leads to a stronger appreciation of the domestic currency, which brings the trade balance even more into negative. As exports decrease and imports increase, demand for domestic goods diminishes, depressing production and offsetting the positive impact of the capital inflow shock. In fact, in the limit case of no financial dollarization, the impact effect on output is negative.

Figure 4.14: Responses to a capital inflow shock to entrepreneurs under standard Taylor rule and different shares of foreign currency borrowing



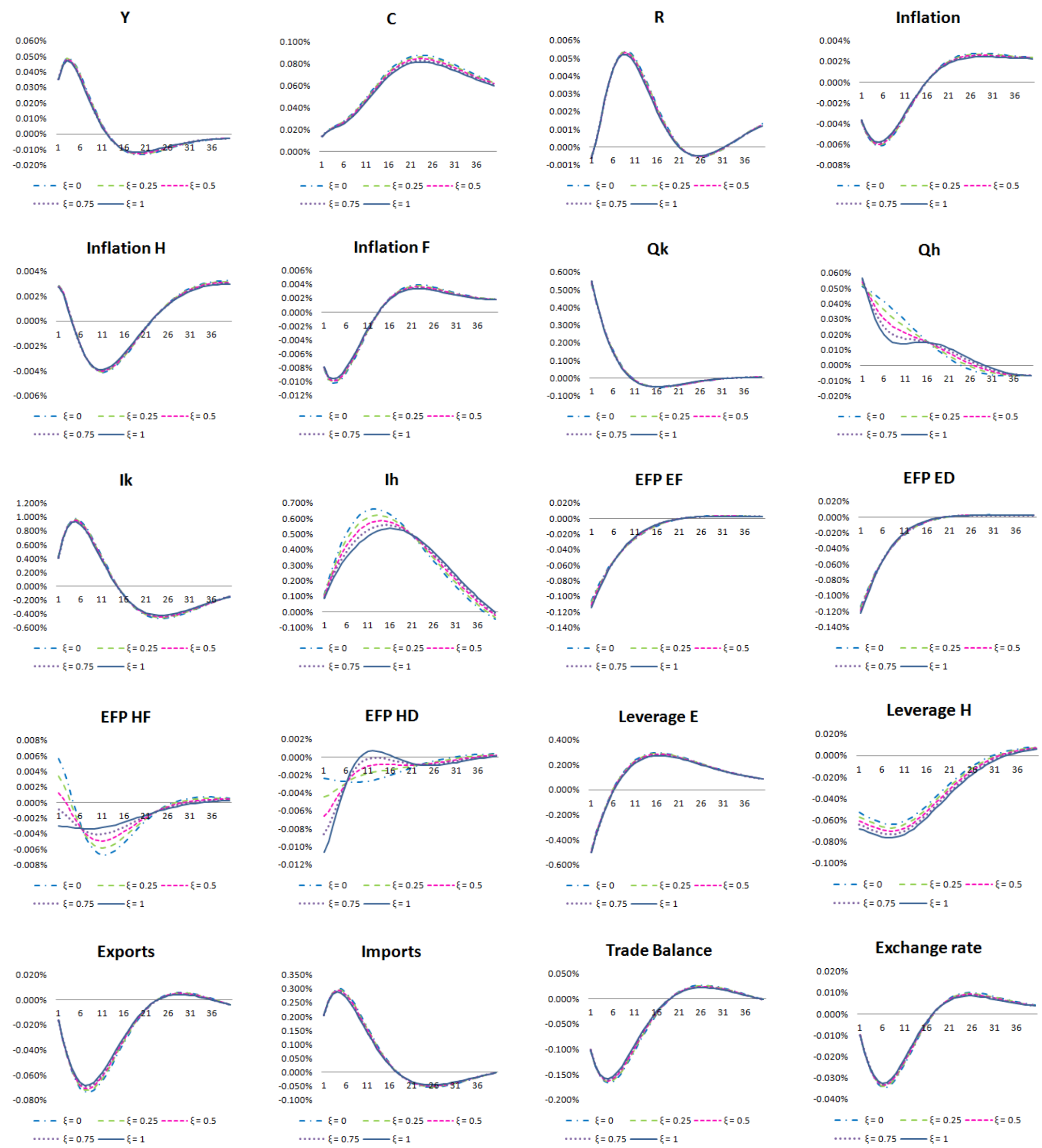
Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.15: Responses to a capital inflow shock to entrepreneurs under Taylor rule + Loan growth and different shares of foreign currency borrowing



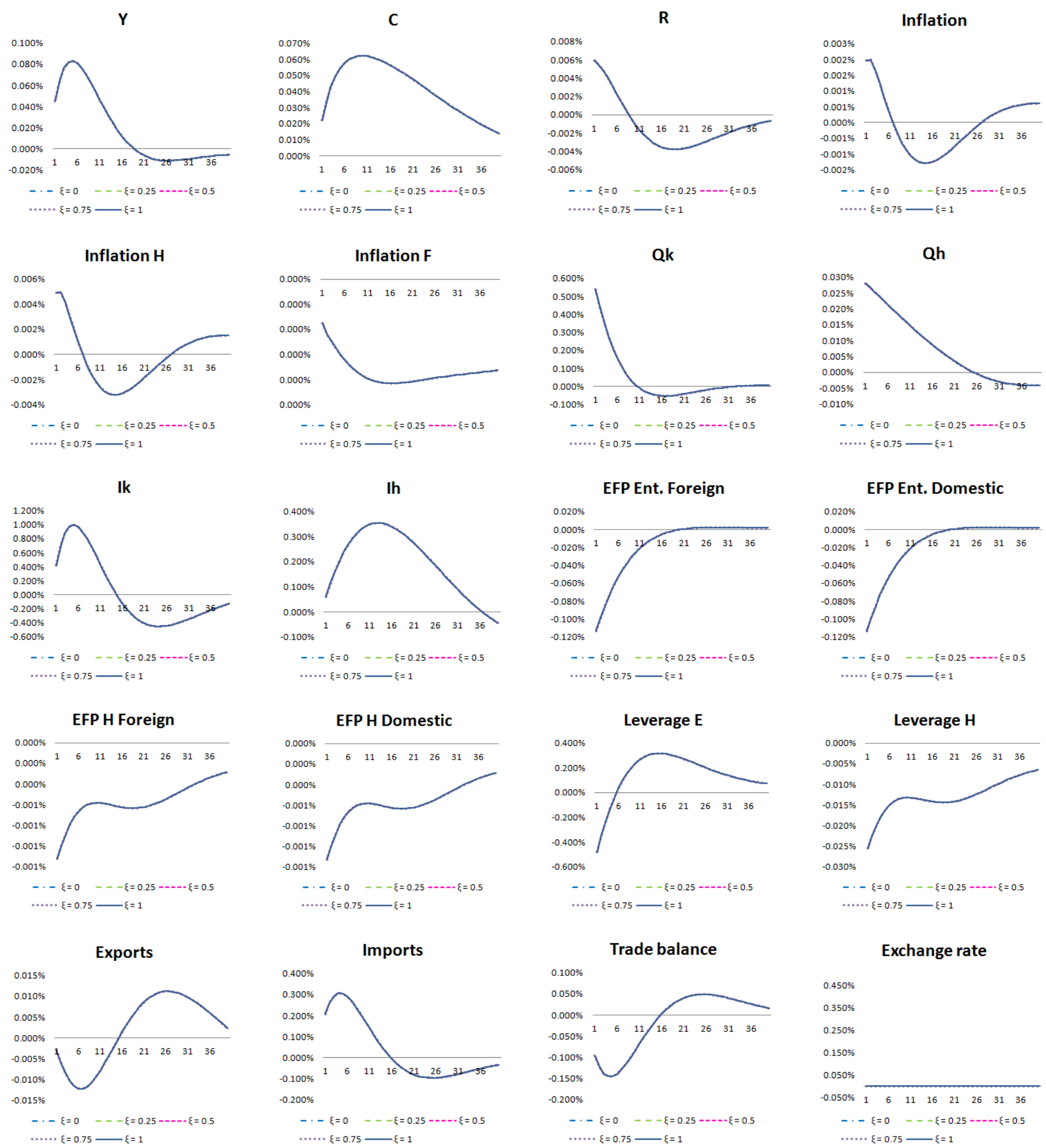
Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.16: Responses to a capital inflow shock to entrepreneurs under Taylor rule + Exchange rate and different shares of foreign currency borrowing



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

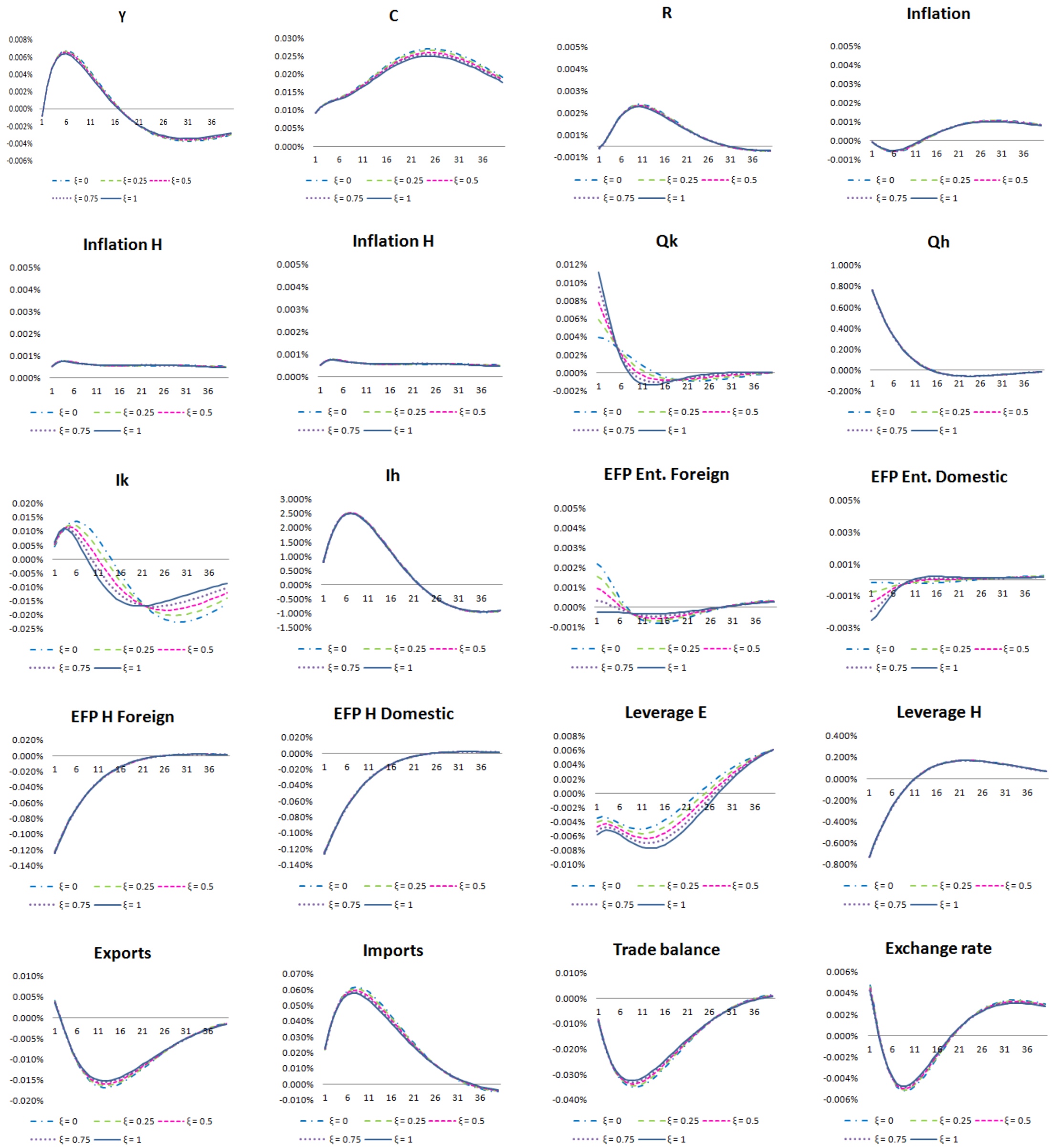
Figure 4.17: Responses to a capital inflow shock to entrepreneurs under Fixed exchange rate regime and different shares of foreign currency borrowing



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

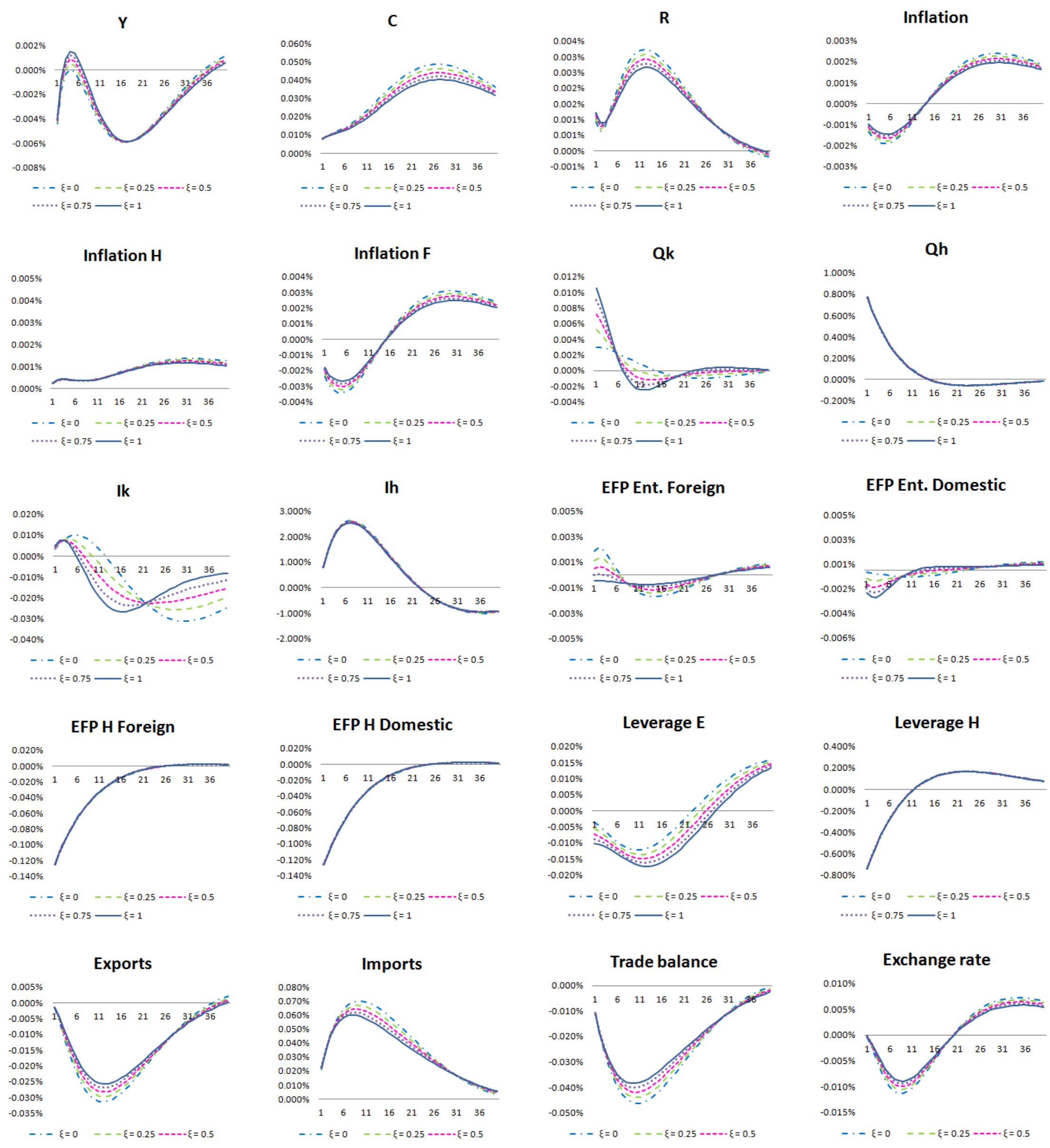
Finally, figures 4.18 to 4.21 depict the impulse-responses to a capital inflow shock to homeowners. The discussion is broadly similar to that of a capital inflow shocks to entrepreneurs. Here, the shock affects directly the external finance premium of homeowners, improving their borrowing conditions and decreasing their leverage. Therefore, homeowners engage in more investment projects, pushing up the price of unfinished houses. The shock has a positive impact on consumption through two main effects. First, the increase in the transfer from homeowners to consumers increases consumers' wealth. Second, the increased supply of finished houses lowers their rental price, which encourages demand. The increase in consumption demand affects both domestic and imported goods. Hence, as demand for domestic goods increases, so does domestic inflation. As imports increase, exports are discouraged, which leads the trade balance to become negative and it puts depreciating pressures on the currency on impact, albeit of a small magnitude. Output decreases on impact, while inflation slightly decreases. In the case of a standard Taylor Rule, the central bank lowers slightly the interest rate in impact, but then slowly increases it as output picks up driven by the increase in domestic demand. This leads the currency to start appreciating. In the case of Taylor Rule augmented with loans growth, the central bank reacts to the increase in credit in the economy by raising the interest rate by a larger amount, which offsets the depreciating pressures on the currency. In case of Taylor Rule augmented with a reaction to the exchange rate, the central bank reacts to the depreciating pressures by raising the interest rate more strongly than in the case of a standard Taylor Rule, which again leads to an appreciation of the exchange rate after a few quarters. Finally, when the central bank pegs the exchange rate, it increases the interest rate on impact to counteract the currency depreciation. In this case, the price of foreign goods remains unchanged and overall inflation rises due to the increase in growth of the domestically produced goods' price.

Figure 4.18: Responses to a capital inflow shock to homeowners under standard Taylor rule and different shares of foreign currency borrowing



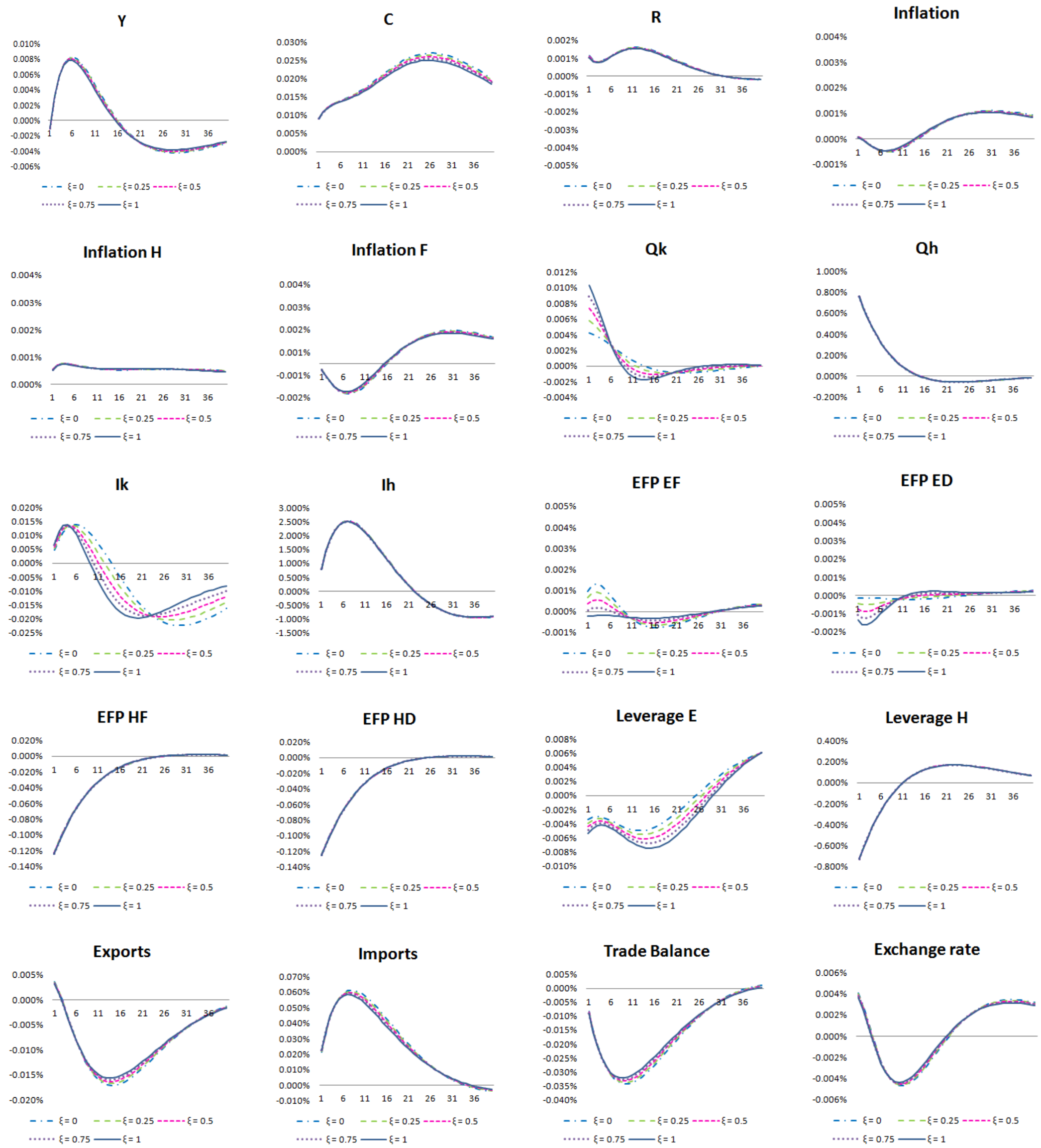
Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.19: Responses to a capital inflow shock to homeowners under Taylor rule + Loan growth and different shares of foreign currency borrowing



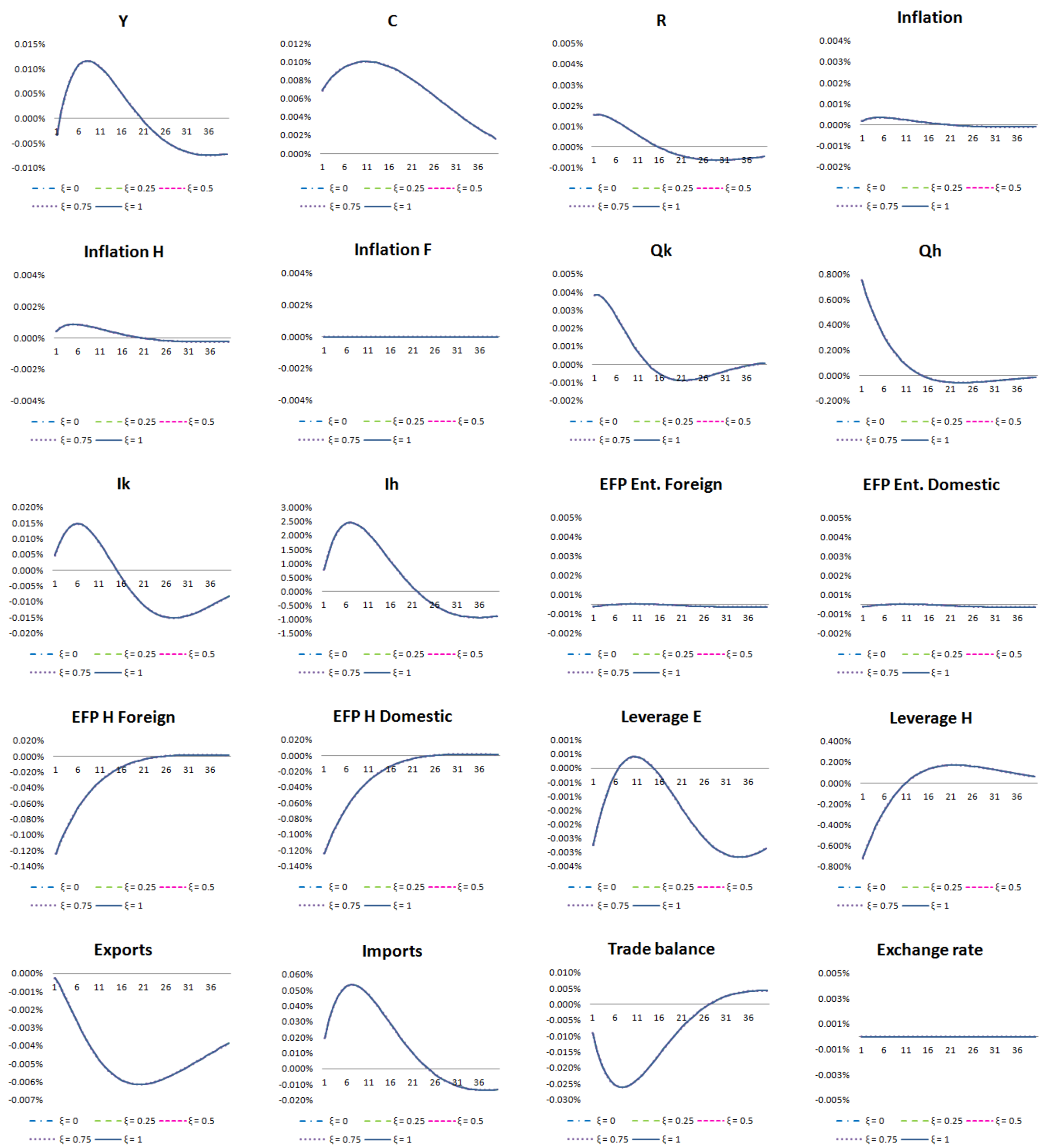
Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.20: Responses to a capital inflow shock to homeowners under Taylor rule + Exchnage rate and different shares of foreign currency borrowing



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

Figure 4.21: Responses to a capital inflow shock to homeowners under Fixed exchange rate regime and different shares of foreign currency borrowing



Note: Responses to a 0.01 standard deviations capital inflow shock, in percentage deviations from the steady state. The response of the domestic interest rate is in basis points

As in the baseline case, we can now derive the optimal monetary policy rules, for different degrees of financial dollarization. In particular, I specify three loss functions the central bank attempts to minimize. In the first scenario, named "Macroeconomic stability", the central bank is only concerned about stabilizing the real economy, hence the loss function is defined in terms of volatility of output and inflation. Furthermore, the central bank considers desirable to smooth the volatility of the domestic interest rate. In the second scenario (named "Financial stability1"), I specify the central bank's loss function as a function of the volatility of aggregate credit growth, in addition to output, inflation and interest rate volatility. In this scenario, the monetary authority of the small open economy considers monetary stability a priority, which translates in a lower weight on credit growth (0.1) than on inflation volatility. The third case (named "Financial stability2") is similar to the second, except that in this case the central bank puts equal weight on inflation and credit growth: hence, in this case, macroeconomic and financial stability are of equal importance in the eyes of the central bank. The results are reported in Table 4.3 below.

Table 4.3: Optimized Taylor rules for different degrees of financial dollarization

	φ_r	φ_π	φ_y	φ_L	φ_S	$Loss$
ξ=1						
Loss MS	0.764	1.364	0.749	0.0874	0.0876	0.4530
Loss FS_1	0.796	1.3605	0.7563	0.0859	0.4862	0.4574
Loss FS_2	0.851	1.385	0.656	0.0937	0.4922	0.4755
$\xi = 0.75$						
Loss MS	0.7658	1.364	0.746	0.0891	0.0876	0.4539
Loss FS_1	0.7908	1.3613	0.7543	0.0675	0.4862	0.4579
Loss FS_2	0.859	1.383	0.670	0.0917	0.4903	0.4745
$\xi = 0.5$						
Loss MS	0.7669	1.365	0.743	0.090	0.087	0.4549
Loss FS_1	0.7876	1.3615	0.754	0.088	0.4859	0.4589
Loss FS_2	0.8726	1.382	0.683	0.088	0.486	0.4739
$\xi = 0.25$						
Loss MS	0.7682	1.365	0.7403	0.0925	0.0874	0.4560
Loss FS_1	0.784	1.361	0.7527	0.090	0.4857	0.4598
Loss FS_2	0.8872	1.3818	0.6959	0.079	0.4775	0.4739
$\xi = 0$						
Loss MS	0.7695	1.366	0.737	0.094	0.0873	0.4571
Loss FS_1	0.7829	1.3621	0.7511	0.0920	0.4855	0.4687
Loss FS_2	0.7918	1.381	0.698	0.0936	0.4881	0.4756

As it was the case in the original version of the model, optimized monetary policy rules are characterized by a quite high degree of inertia, which increases the more the central bank is concerned with financial stability. Furthermore, it decreases with the share of foreign currency borrowing in the model. As financial dollarization decreases, there is less need for the monetary authority to smooth interet rate movements that could lead to excessive swings in the exchange rate. The optimal coefficients on inflation and output are bradly similar across specifications and degree of foreign currency borrowing. As in the baseline case, reacting to loans growth is still not optimal, as for all considered specifications the optimized coefficient is very small. In fact, even in this version of the model the opportunity cost of lending for lenders is the foreign interest rate, which is not affected by the monetary policy conduct of the small open economy. In the limit case of 100% domestic currency borrowing, if the central bank reacts to loan growth by increasing the policy rate, it won't impact the financial sector direclty, since contracts are stipulated using the foreign interest rate as reference risk-free rate. The interest rate hike will impact intertemporal consumption and saving decisions, and the exchange rate, but it won't, at least in the first round effect, impact on borrowers' financing conditions. Finally, as in the baseline case, when the central bank is only concerned with macroeconomic stability, reacting to exchange rate movements is not optimal. However, when financial stability is an objective of the monetary authority, the optimal coefficient on exchange rate depreciation is positive, and it is slightly higher as the degree of financial dollarization increases.

CHAPTER 5
CROSS-COUNTRY BALANCE SHEET INTERDEPENDENCE AND THE CHOICE OF EXCHANGE RATE REGIME

Understanding the role of banks in cross-border finance has become an urgent research priority since the onset of the global crisis, as issues related to cross-border banking have played a central role in its origin and propagation. The tightening of financial linkages is a phenomenon that gained particular importance for the Central and Eastern European countries which joined the European Union in the enlargement waves of 2004 and 2007. The drawbacks of financial interdependence became evident during the financial crisis. As the new EU member states weren't directly exposed to toxic assets, in a financially autarkic world they would have been hit by the crisis through exchange rate and external demand effects. However, given the high degree of financial interdependence with Western Europe (in turn heavily connected to American banks), the new EU member states got dragged in the spiral and suffered major losses in terms of GDP growth. In particular, the greatest magnitude of the economic downturn was observed in countries which adopted a pegged exchange rate regime. Motivated by this background, this chapter studies the interplay between exchange rate regimes and financial integration in a two-country, general equilibrium setting characterized by real and financial frictions.

The analysis presented in this essay has multiple purposes. First, it analyzes the transmission mechanism of foreign real and financial shocks under different exchange rate regimes and different degrees of cross-border lending relationships. Second, it addresses the issue of the ranking of fixed and flexible exchange rate regimes and its relationship to the strength of cross-border borrowing. In particular, the relative performance of exchange rate regimes is evaluated from the point of view of both the Home country's central bank and Home country households' welfare. More specifically, the relationship between exchange rate regime and cross-border borrowing is evaluated for different objectives of the Home country's central bank.

The model portrays two countries with symmetric structures but different sizes. It is assumed that the home country (denoted by the superscript H) is of size n, while the foreign country (F) is of size $(1-n)$, where $n \in [0,1]$. In the calibration, I set $n \rightarrow 0$, allowing me to model the Home country as a small open economy while still allowing for trade and financial linkages. On the real side, the two economies are characterized by imperfectly competitive product and labor markets, coupled with Calvo pricing and wage setting whose implied inefficiencies warrant an explicit role for monetary policy. Each economy produces a variety of internationally traded intermediate goods. Households in each country can access the international financial market and invest in domestic and foreign instruments. Credit markets, however, are characterized by frictions at different stages of the intermediation process, in the spirit of Ueda (2012). In particular, in each country a continuum of financial intermediaries lends to entrepreneurs in both countries and finances its loan portfolio by collecting deposits from domestic and foreign households. The presence of asymmetric information between households and financial intermediaries and between financial intermediaries and entrepreneurs implies a costly state verification problem leading to an optimal contract whereby the cost of external finance is tied to balance sheet conditions. Hence, in contrast with the standard model of the financial accelerator model, the leverage of financial institutions, together with that of entrepreneurs, plays a role in determining the tightness of credit conditions in the economy. Furthermore, integration in international credit markets implies interdependency of credit conditions between countries, strengthening the degree of business cycle correlation, as shown by Ueda (2012).

5.1 The model

5.1.1 Households

In each country the preferences of the representative household are represented by the utility function:

$$E_t\left\{U(C_t, H_t)\right\} = E_t\left\{\sum_{t=0}^{\infty}\beta^t\frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \chi_H\frac{H_t^{1+\varphi}}{1+\varphi}\right\} \tag{5.1}$$

Where C_t and H_t are composites of consumption goods and labor services respectively, and h is the degree of consumption habit formation. The consumption index C is a Cobb-Douglas aggregate of home produced ($C_{H,t}$) and imported ($C_{F,t}$) goods, where γ is the share of domestic good in the consumption basket of Home households:

$$C_t = \frac{C_{H,t}^{\gamma}C_{F,t}^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}$$

As in De Paoli (2009) and Corsetti and Müller (2011), I assume that the relative weight of domestic and foreign goods in the consumption bundle is a function of the relative country size and the degree of trade openness. In particular, I assume $(1-\gamma) = (1-n)\lambda$, where $\lambda \in (0, 1)$ is the openness parameter: when $\lambda = 1$ there is no home bias, and the share of imported goods in consumption equals $(1-n)$. A similar specification holds for the Foreign economy, where the aggregate consumption bundle is

$$C_t^* = \frac{C_{H,t}^{*\gamma^*}C_{F,t}^{*1-\gamma^*}}{\gamma^{*\gamma^*}(1-\gamma^*)^{1-\gamma^*}}$$

and $\gamma^* = n\lambda$.[79] Hence, in the limit case when the Home economy becomes small ($n \to 0$), $\gamma \to (1-\lambda)$ and $\gamma^* \to 0$, the Foreign country becomes closed, but, as long as $\lambda > 0$, the Home country consumes Foreign goods.[80]

The consumption sub-indices $C_{H,t}, C_{F,t}, C^*_{H,t}$ and $C^*_{F,t}$ are in turn aggregates of intermediate goods produced in the Home and foreign country, i.e.:

$$C_{H,t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon}} \int_0^n c_{t,H}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} ; \quad C^*_{H,t} = \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon}} \int_0^n c^*_{t,H}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}$$
$$C_{F,t} = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon}} \int_n^1 c_{t,F}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} ; \quad C^*_{F,t} = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon}} \int_n^1 c^*_{t,F}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

Where $\varepsilon > 0$ is the elasticity of substitution between different varieties of intermediate goods. The price indices corresponding to the consumption bundles in the two countries are, respectively:

$$P_t = P^{\gamma}_{H,t} P^{1-\gamma}_{F,t} \tag{5.2}$$

$$P^*_t = P^{*\gamma^*}_{H,t} P^{*1-\gamma^*}_{F,t} \tag{5.3}$$

Households choose the optimal allocation of expenditure between domestic and imported consumption goods solving an expenditure minimization problem, which results in the following optimality conditions:

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79 Here I follow a notation whereby subscripts refer to the country where the good is produced (H or F). The presence (absence) of an asterisk indicates that the good is consumed or used as an input in the foreign (domestic) country.

80 Specifically, the consumption shares are defied as: $\gamma = 1 - (1-n)\lambda$, $(1-\gamma) = (1-n)\lambda$ in the Home country and $\gamma^* = n\lambda$, $(1-\gamma^*) = 1 - n\lambda$ in the Foreign country. Therefore, when the Home economy becomes very small, $n \to 0$, we have that: $\gamma = 1-\lambda$, $(1-\gamma) = \lambda$ and $\gamma^* = 0$, $(1-\gamma^*) = 1$. Therefore, if $n \to 0$, the price indices in the two countries reduce to $P_t = P^{1-\lambda}_{H,t} P^{\lambda}_{F,t}$ and $P^*_t = P^*_{F,t}$. This implies that, while the Foreign country prices still matter in the aggregate price level of the Home country, the price level of the Foreign country is not influenced by prices of Home country goods.

$$C_{H,t} = \gamma \left(\frac{P_{H,t}(j_H)}{P_{H,t}} \right)^{-\varepsilon} \left(\frac{P_{H,t}}{P_t} \right)^{-1} C_t \tag{5.4}$$

$$C_{F,t} = (1-\gamma) \left(\frac{P_{F,t}(j_F)}{P_{F,t}} \right)^{-\varepsilon} \left(\frac{P_{F,t}}{P_t} \right)^{-1} C_t \tag{5.5}$$

Following Schmitt-Grohé and Uribe (2006), I assume the existence of a continuum of labor markets of measure 1 indexed by $i \in [0,1]$, in each of which wages are set by a monopolistically competitive union facing downward sloping labor demand, given by $\left(\frac{W_t(i)}{W_t}\right)^{-\varepsilon_w} H_t^d$, where $W(i)_t$ denotes the wage set by the wage union for the $i-th$ labor market, H_t^d denotes labor demand by firms, ε_w represents the elasticity of substitution between different labor types, and the aggregate wage prevailing in the economy is given by

$$W_t = \left[\int_0^1 W_t(i)^{1-\varepsilon_w} di \right]^{\frac{1}{1-\varepsilon_w}} \tag{5.6}$$

Given the contracted $W_t(i)$, the union is assumed to supply enough labor to satisfy demand, i.e. $H_t(i) = \left(\frac{W_t(i)}{W_t}\right)^{-\varepsilon_w} H_t^d$. This condition, coupled with the requirement that the total labor supply satisfies the market clearing condition $H_t = \int_0^1 H_t(i) di$, yields:

$$H_t = \left(\frac{W_t(i)}{W_t} \right)^{-\varepsilon_w} H_t^d \tag{5.7}$$

The union then takes W_t and H_t^d as given and sets the optimal wage $\tilde{W}_t(i)$ so as to equate the union's expected average marginal return with the marginal cost of supplying labor. However, in doing so the union faces nominal rigidities in the Calvo fashion. Specifically, in each period the wage can be optimized only in a fraction $(1-\theta^w)$ of labor markets. In the remaining fraction θ^w the real wage is indexed to past inflation and it is therefore given by:

$$W_t(i) = W_{t-1}(i)\pi_{t-1}$$

The reoptimizing union sets the optimal wage $\tilde{W}_t(i)$ so as to maximize[81]:

$$E_t \sum_{k=0}^{\infty} (\beta\theta^w)^k \mu_{t+k} \left(\frac{\tilde{W}_t \prod_{i=1}^{k} \left(\frac{\pi_{t+i-1}}{\pi_{t+i}}\right)}{W_{t+k}} \right)^{-\varepsilon_w} H_t^d \left[\tilde{W}_t \prod_{i=1}^{k} \left(\frac{\pi_{t+i-1}}{\pi_{t+i}}\right) - \frac{U'_H}{\mu_{t+k}} \right]$$

Where the first term in parenthesis represents the marginal gain for the union of supplying an extra unit of labor, and the second term represents the marginal disutility of doing so. The first order conditions can be formulated in the following recursive fashion:

$$K_t^w = \left(\frac{\varepsilon_w - 1}{\varepsilon_w}\right) \tilde{W}_t \mu_t H_t \left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} + \beta\theta^w \left(\frac{\pi_{H,t+1}}{\pi_{H,t}} \frac{\tilde{W}_{t+1}}{\tilde{W}_t}\right)^{\varepsilon_w - 1} K_{t+1}^w \quad (5.8)$$

$$F_t^w = \chi_H \left(H_t^d\right)^{\varphi} \left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} H_t + \beta\theta^w \left(\frac{\pi_{H,t+1}}{\pi_{H,t}} \frac{\tilde{W}_{t+1}}{\tilde{W}_t}\right)^{\varepsilon_w} F_{t+1}^w \quad (5.9)$$

$$K_t^w = F_t^w \quad (5.10)$$

It follows from (5.6) and staggered wage setting that the law of motion of the aggregate wage is[82]:

$$W_t = \left[(1-\theta^w) \tilde{W}_t^{1-\varepsilon_w} + \theta^w \left(W_{t-1}(i)\pi_{t-1}\right)^{1-\varepsilon_w} \right]^{\frac{1}{1-\varepsilon_w}} \quad (5.11)$$

Besides labor income, households receive dividends from ownership of domestic firms and returns from their investments in domestic and international asset

[81] In what follows I drop the index (i) as all firms allowed to reoptimize in a given period set the same wage.

[82] Staggered wage setting implies an inefficient wage dispersion, arising from the fact that wages are not set simultaneously. The law of motion of such wage dispersion, defined as $\Delta_{w,t} = \int_0^1 \left(\frac{W_t(i)}{W_t}\right)^{-\varepsilon_w} di$, is given by:

$$\Delta_{w,t} = (1-\theta_w) \left(\frac{W_t}{\tilde{W}_t}\right)^{\varepsilon_w} + \theta_w \left(\frac{W_t}{W_{t-1}} \frac{\pi_{H,t}}{\pi_{H,t-1}}\right)^{\varepsilon_w} \Delta_{w,t-1}$$

So that the effective labor supply is $H_t = \frac{H_t^d}{\Delta_{w,t}}$.

markets. Households have access to a complete set of internationally traded Arrow-Debreu securities. They acquire a portfolio $B(s_{t+1})$ of real state-contingent securities, each of which pays one unit in $t+1$ at the occurrence of the state of nature s_{t+1}, which carries the pricing kernel $m(s_{t+1}|s_t)$. Furthermore, they can invest in real deposits in Home or Foreign financial intermediaries (denoted respectively D_t and D_t^*)[83], which yield a one period return of $D_t R_t$ and $D_t^* R_t^*$.

The budget constraint of the representative household in the Home country can then be formulated in real terms as:

$$C_t + D_t + \varepsilon_t D_t^* + \sum_{s_{t+1}} m(s_{t+1}|s_t) B(s_{t+1}) \leq H_t \int_0^1 W_t(i) \left(\frac{W_t(i)}{W_t} \right)^{-\varepsilon_w} di +$$
$$+ R_{t-1} D_{t-1} + R_{t-1}^* \varepsilon_{t-1} D_{t-1}^* + B_t + \Pi_t^H - T_t$$

Where $\varepsilon_t = \frac{S_t P_t^*}{P_t}$ is the real exchange rate. The first order conditions deriving from the household's optimization problem define the optimal intertemporal consumption path and labor supply which, denoting as μ_t the Lagrange multiplier associated with the budget constraint, are given by:

$$\mu_t = (C_t - hC_{t-1})^{-\sigma} \tag{5.12}$$
$$\beta E_t \left\{ \frac{\mu_{t+1}}{\mu_t} \frac{\pi_{t+1}}{\pi_t} \right\} = m(s_{t+1}|s_t); \ \frac{1}{R_t} = \sum_{s_{t+1}} m(s_{t+1}|s_t) \tag{5.13}$$
$$w_t = \frac{\varepsilon_w}{\varepsilon_w - 1} \frac{\chi_H H_t^{\varphi}}{\mu_t} \tag{5.14}$$

Where equation (5.13) results from maximization with respect to bonds and deposits. In particular, it states that the price of the state contingent portfolio relates to the changes in marginal utility of consumption and that, in equilibrium, the expected

[83] Although deposits are redundant, their presence is needed as they are demanded from domestic and foreign financial institutions, and necessary to satisfy the market clering conditions in the general equilibrium. For a similar specification, cfr. Faia (2002).

return of the state contingent portfolio has to equal that of deposits (arbitrage condition). Note that in the absence of staggered wage setting, (5.14) reduces to a standard labor supply equation.

An analogous utility maximization problem applies in the Foreign economy. In particular, the Foreign counterpart of equation (5.13) reads:

$$\beta E_t \left\{ \frac{\mu^*_{t+1}}{\mu^*_t} \frac{\pi_{t+1}}{\pi_t} \frac{\varepsilon_t}{\varepsilon_{t+1}} \right\} = m(s_{t+1}|s_t); \; \frac{1}{R^*_t} \frac{\varepsilon_t}{\varepsilon_{t+1}} = \sum_{s_{t+1}} m(s_{t+1}|s_t) \tag{5.15}$$

From (5.13) and (5.15) I obtain:

$$\frac{\mu_{t+1}}{\mu_t} = \frac{\mu^*_{t+1}}{\mu^*_t} \frac{\varepsilon_t}{\varepsilon_{t+1}} \tag{5.16}$$

$$\frac{1}{R_t} = \frac{1}{R^*_t} \frac{\varepsilon_t}{\varepsilon_{t+1}} \tag{5.17}$$

From which an expectational version of the uncovered interest parity condition results:

$$\sum_{s_{t+1}} m(s_{t+1}|s_t) \left[R_t - R^*_t \frac{\varepsilon_{t+1}}{\varepsilon_t} \right] = 0$$

5.1.2 Production

There exist a continuum of monopolistic intermediate good producers in each country, indexed j_H and j_F respectively. Each producer operates under monopolistic competition and is owned by households, with the demand for its products given by:

$$Y_t\left(j_H\right) = \left(\frac{P_{H,t}(j_H)}{P_{H,t}} \right)^{-\varepsilon_H} Y_t$$

Producers use capital and three types of labor inputs (H_t, H^E_t and H^F_t, supplied respectively by households, entrepreneurs and bankers) to produce differentiated goods. The production function for domestic intermediate good producers is given by:

$$Y_t\left(j_H\right) = A_t K_t^{\alpha}\left(j_H\right) H\left(j_H\right)_t^{(1-\alpha)(1-\Omega_E-\Omega_F)} H_t^E\left(j_H\right)^{(1-\alpha)\Omega_E} H_t^F\left(j_H\right)^{(1-\alpha)\Omega_F} \tag{5.18}$$

Where α is the share of capital in production, Ω_E and Ω_F are the shares of entrepreneurial and bankers' labor in production. Cost minimization implies the following standard factor demand functions, where r_t^K denotes the rental rate of capital:

$$W_t = MC_t\left(1-\alpha\right)\left(1-\Omega_E-\Omega_F\right)\frac{Y_t}{H_t} \tag{5.19}$$

$$W_t^E = MC_t\left(1-\alpha\right)\Omega_E\frac{Y_t}{H_t^E} \tag{5.20}$$

$$W_t^F = MC_t\left(1-\alpha\right)\Omega_F\frac{Y_t}{H_t^F} \tag{5.21}$$

$$r_t^K = MC_t\alpha\frac{Y_t}{K_t} \tag{5.22}$$

5.1.3 Price setting

Price setting is staggered. In each period, only a fraction $(1-\theta_H)$ of firms are allowed to reset their price optimally. The fraction θ_H that is not allowed to optimize in each period sets the price equal to that prevailing in the previous period, indexing it to past inflation at a rate γ_p and to the steady state inflation rate at rate $\left(1-\gamma_p\right)$. Hence, denoting as $\tilde{P}_{H,t}$ the optimal reset price, the law of motion of the domestic good price evolves as:

$$P_{H,t} = \left[\theta_H\left(P_{H,t-1}\pi_{t-1}^{\gamma_p}\left(\pi^{ss}\right)^{1-\gamma_p}\right)^{1-\varepsilon_H} + (1-\theta_H)\tilde{P}_{H,t}^{1-\varepsilon_H}\right]^{\frac{1}{1-\varepsilon_H}} \tag{5.23}$$

The firm then chooses the optimal price $\tilde{P}_{H,t}(j_H)$ so as to maximize the discounted sum of future real profits. Hence, each producer maximizes:

$$E_t\left\{\sum_{k=0}^{\infty}(\beta\theta_H)^k\frac{\mu_{t+k}}{\mu_t}\left[\begin{array}{c}\left(\frac{\tilde{P}_{H,t}(j_H)}{P_{H,t+k}}\prod_{i=1}^{k}\pi_{t+i-1}^{\gamma_p}\left(\pi^{ss}\right)^{1-\gamma_p}\right)^{1-\varepsilon_H}\\ -mc_{t+k}\left(\frac{\tilde{P}_{H,t}(j_H)}{P_{H,t+k}}\prod_{i=1}^{k}\pi_{t+i-1}^{\gamma_p}\left(\pi^{ss}\right)^{1-\gamma_p}\right)^{-\varepsilon_H}\end{array}\right]Y_{t+k}\right\}$$

The first order conditions can be written in a recursive manner as follows:

$$\frac{\tilde{P}_{H,t}}{P_{H,t}} = \frac{\varepsilon_H}{\varepsilon_H-1}\frac{F_{H,t}}{D_{H,t}} \tag{5.24}$$

$$F_{H,t} = \frac{\mu_t}{P_t}P_{H,t}mc_{H,t}Y_t^H+\beta\theta_H E_t\left\{\left(\pi_{t+1}^H\right)^{\varepsilon_H}F_{H,t+1}\right\} \tag{5.25}$$

$$D_{H,t} = \frac{\mu_t}{P_t}P_{H,t}Y_t^H+\beta\theta_H E_t\left\{\left(\pi_{t+1}^H\right)^{\varepsilon_H-1}D_{H,t+1}\right\} \tag{5.26}$$

5.1.4 Capital goods producers

Capital producers operate in a regime of perfect competition. In each period, they combine investment goods (I_t, with price P_t^I) and old undepreciated capital ($(1-\delta)K_t$, purchased from entrepreneurs at price $Q_{H,t}$) to produce new capital goods, which will be sold at the real price $Q_{H,t}$. Investment is subject to adjustment costs, represented by the function $\Phi_t=\frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2$ (Smets and Wouters (2003)). Capital producers choose the optimal amount of investment[84] so as to maximize the following profit function:

$$E_t\left\{\sum_{k=0}^{\infty}\beta^k\frac{\mu_{t+k}}{\mu_t}\frac{1}{P_{H,t+k}}\left[q_{H,t}P_{H,t+k}\left(\left(1-\delta\right)K_{t+k}+\left(1-\Phi_t\right)I_{t+k}-K_{t+k}\right)-P_{H,t+k}I_{t+k}\right]\right\}$$

[84] The investment bundle has a similar composition as the consumption bundle, and can therefore be defined as:

$$I_t=\frac{I_{H,t}^{\gamma}I_{F,t}^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}$$

The first order condition with respect to I_t yields:

$$\begin{aligned} 1 &= q_{H,t}\left[1-\frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2-\kappa\left(\frac{I_t}{I_{t-1}}-1\right)\left(\frac{I_t}{I_{t-1}}\right)\right]+ \\ &\quad +\beta E_t\left\{\frac{\mu_{t+1}}{\mu_t}q_{H,t+1}\left[\kappa\left(\frac{I_{t+1}}{I_t}-1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]\right\} \end{aligned} \tag{5.27}$$

Where $q_{H,t}$ is the real price of the capital stock defined as $\frac{Q_{H,t}}{P_{H,t}}$. The law of motion of the economywide capital stock is:

$$K_{t+1}=\left[1-\frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2\right]I_t+(1-\delta)\,K_t \tag{5.28}$$

5.1.5 Entrepreneurs, banks and international lenders

Credit markets are characterized by chained credit contracts in the spirit of Hirakata et al. (2009) and Ueda (2012). Entrepreneurs in a given country borrow from domestic and foreign financial intermediaries (banks) to finance capital purchases. In turn, financial intermediaries in each country borrow from domestic and foreign investors in order to finance their loan portfolio. The presence of financial frictions in both contracts (i.e. between entrepreneurs and financial intermediaries and between financial intermediaries and international investors) makes the external finance premium faced by entrepreneurs in each country dependent on balance sheet conditions in the other country.

In each country a continuum of entrepreneurs purchase unfinished capital goods from capital producers and transform them into finished capital goods through a stochastic technology. Capital is then rented to firms at the rental rate r_t^K. Entrepreneurs finance capital purchases partly using their own net worth ($NW_{H,t}^E$) and partly borrowing from domestic and foreign financial intermediaries. Specifically, entrepreneurs in the home country use a fraction $\left(1-\tau_H^E\right)$ of net worth to borrow from home intermediaries and purchase an amount $\left(1-\tau_H^E\right) Q_{H,t} K_{HH,t}$ of capital, and a fraction τ_H^E to borrow from foreign intermediaries and purchase $\tau_H^E Q_{H,t} K_{HF,t}$.[85] Entrepreneurs in the foreign economy behave analogously. The credit contract is characterized by asymmetric information in the spirit of Bernanke, Gertler and Gilchrist (1999).

Denote $R_{HH,t}^E$ and $R_{HF,t}^E$ the expected return from capital investment of home entrepreneurs borrowing from domestic and foreign financial intermediaries respectively. The return to capital is made of the return from selling capital to production firms and the return from selling undepreciated capital to capital producers[86]:

$$R_{HH,t}^E = \frac{r_t^K + (1-\delta) Q_{H,t}}{Q_{H,t-1}}$$
$$R_{HF,t}^E = \frac{r_t^K + (1-\delta) Q_{H,t}}{Q_{H,t-1}}$$

Contract between financial intermediaries and entrepreneurs

Let us consider the problem of financial intermediaries in the home country, which stipulate credit contracts with entrepreneurs in the home and foreign country.

Entrepreneurs in the Home country own net worth $NW_{H,t}^E$ and use a fraction $\left(1-\tau_H^E\right)$ of it to finance a capital expenditure of $\left(1-\tau_H^E\right) Q_{H,t} K_{HH,t}$. Hence, the Home entrepreneur borrows an amount given by $L_{HH,t}^E = \left(1-\tau_H^E\right)\left(Q_{H,t} K_{HH,t} - NW_{H,t}^E\right)$ from domestic financial intermediaries. Entrepreneurs borrowing in the Home country are subject to a stochastic shock $\omega_{HH,t+1}^E$ following a lognormal distribution with

85 In what follows, the subscripts $i, j = H, F$ refer, respectively, to the nationality of the agent and the origin of the loan. Furhtermore, the superscript E pertains to entrepreneurs, while F denotes financial intermediaries. Therefore, R_{HF}^E denotes the return to capital for entrepreneurs in country H borrowing from country F.

86 Note that capital is homogeneous within each country. The notation K_{HH} and K_{HF} is introduced for convenience in the calulations, but within each country there is one capital stock (which results from aggregating the quantitites purchased by the two types of entrepreneurs) and one asset price Q.

$E\left(\omega^E_{HH,t+1}\right) = 1$[87]. The ex-post return to capital is then $R^E_{HH,t+1}\omega^E_{HH,t+1}$. Foreign entrepreneurs borrowing from domestic financial intermediaries behave analogously, using a fraction τ^E_F of their net worth $NW^E_{F,t}$ to borrow $L^E_{FH,t} = \tau^E_F\left(Q_{F,t}K_{FH,t} - NW^E_{F,t}\right)$ from domestic financial intermediaries, and they are characterized by the stochastic technology $\omega^E_{FH,t+1}$.

The optimal contract (see Calstrom ad Fuerst (1997)) specifies a state-contingent loan rate $Z^E_{ij,t+1}$ and a threshold $\bar{\omega}^E_{ij,t+1}$, such that for realizations $\omega^E_{ij,t+1} > \bar{\omega}^E_{ij,t+1}$ entrepreneurs repay the loan at the contractual rate and keep the remaining proceeds of their investment, while for realizations $\omega^E_{ij,t+1} < \bar{\omega}^E_{ij,t+1}$, entrepreneurs default on their debt, financial intermediaries pay a monitoring cost to verify entrepreneurial output and seize the entrepreneur's remaining assets, leaving the defaulting entrepreneur with a zero payoff. It is then possible to define the threshold productivity level as the minimum realization of productivity that allows entrepreneurs to repay their debts. For domestic and foreign entrepreneurs borrowing from Home financial intermediaries the thresholds ($\bar{\omega}^E_{HH,t+1}$ and $\bar{\omega}^E_{FH,t+1}$) are defined as:

$$\bar{\omega}^E_{HH,t+1}R^E_{HH,t+1}Q_{H,t}K_{HH,t} = Z^E_{HH,t+1}\left(Q_{H,t}K_{HH,t} - NW^E_{H,t}\right)$$
$$\bar{\omega}^E_{FH,t+1}R^E_{FH,t+1}Q_{F,t}K_{FH,t} = Z^E_{FH,t+1}\left(Q_{F,t}K_{FH,t} - NW^E_{F,t}\right)$$

Where the left hand side represents the return to the entrepreneur corresponding to productivity level $\bar{\omega}^E_{ij,t+1}$, and the right hand side represents the required repayments on the contracted loan.

The expected returns of Home and Foreign entrepreneurs from the contract with domestic financial intermediaries are given by the return of the capital invest-

[87] As in Bernanke, Gertler and Gilchrist (1999) I assume that the stochastic shock is iid across entrepreneurs and time, and follows a log-normal distribution $\omega^E_{ij} \sim \log N(-\frac{\sigma^2_E}{2}, \sigma^2_E)$, where σ^2_E represents the variance of the underlying Normal distribution. In what follows, the density of the idiosyncratic shock is denoted as $f(\cdot)$ and its cumulative distribution as $F(\cdot)$. Foreign entrepreneurs are characterized by an idiosyncratic shock with the same characteristics.

ment minus loan repayment in case entrepreneurs do not default, and zero otherwise. Formally, the expected return of entrepreneurs in the Home and Foreign country borrowing from Home country banks are, respectively:

$$\left(1-\tau_H^E\right) R_{HH,t+1}^E Q_{H,t} K_{HH,t} \left[\begin{array}{c} \int_{\bar{\omega}_{HH,t+1}^E}^{\infty} \omega_{HH,t+1}^E f(\omega_{HH,t+1}^E) d\omega_{HH,t+1}^E + \\ -\bar{\omega}_{HH,t+1}^E \int_{\bar{\omega}_{HH,t+1}^E}^{\infty} f(\omega_{HH,t+1}^E) d\omega_{HH,t+1}^E \end{array} \right]$$
$$\tau_F^E R_{FH,t+1}^E Q_{F,t} K_{FH,t} \left[\begin{array}{c} \int_{\bar{\omega}_{FH,t+1}^E}^{\infty} \omega_{FH,t+1}^E f(\omega_{FH,t+1}^E) d\omega_{FH,t+1}^E + \\ -\bar{\omega}_{FH,t+1}^E \int_{\bar{\omega}_{FH,t+1}^E}^{\infty} f(\omega_{FH,t+1}^E) d\omega_{FH,t+1}^E \end{array} \right]$$

Which, defining

$$\begin{aligned} \Gamma_{HH}^E\left(\bar{\omega}_{HH,t+1}^E\right) &= \bar{\omega}_{HH,t+1}^E \left(1 - \int_0^{\bar{\omega}_{HH,t+1}^E} f(\omega_{HH,t+1}^E) d\omega_{HH,t+1}^E\right) + \\ &+ \int_0^{\bar{\omega}_{HH,t+1}^E} \omega_{HH,t+1}^E f(\omega_{HH,t+1}^E) d\omega_{HH,t+1}^E \\ \Gamma_{FH}^{E*}\left(\bar{\omega}_{FH,t+1}^E\right) &= \bar{\omega}_{FH,t+1}^E \left(1 - \int_0^{\bar{\omega}_{FH,t+1}^E} f(\omega_{FH,t+1}^E) d\omega_{FH,t+1}^E\right) + \\ &+ \int_0^{\bar{\omega}_{FH,t+1}^E} \omega_{FH,t+1}^E f(\omega_{FH,t+1}^E) d\omega_{FH,t+1}^E \end{aligned}$$

can be rewritten as:

$$\begin{array}{l} \left[1-\Gamma_{HH}^E\left(\bar{\omega}_{HH,t+1}^E\right)\right]\left(1-\tau_H^E\right) R_{HH,t+1}^E Q_t K_{HH,t} \\ \left[1-\Gamma_{FH}^{E*}\left(\bar{\omega}_{FH,t+1}^{E*}\right)\right] \tau_F^E R_{FH,t+1}^E Q_{F,t} K_{FH,t} \end{array}$$

Where $\left[1-\Gamma_{ij}^E\left(\bar{\omega}_{ij,t+1}^E\right)\right]$ represents the share of payoff captured by the entrepreneur, i.e. the payoff from her capital investment minus loan repayments multiplied by the probability that the entrepreneur does not default[88].

[88] Recall that given a pdf $f(\omega)$, $\int_0^{\bar{\omega}} f(\omega) d\omega = \Pr(\omega \leq \bar{\omega})$, which in this case corresponds to the

Entrepreneurs engage in the debt contract only if the expected return of doing so is at least equal to the payoff they would obtain if they invested only their own net worth. Hence, the following participation constraints for domestic and foreign entrepreneurs have to hold:

$$\left[1-\Gamma_{HH}^{E}\left(\bar{\omega}_{HH,t+1}^{E}\right)\right] R_{HH,t+1}^{E} Q_{H,t} K_{HH,t} \geq R_{HH,t+1}^{E} NW_{H,t}^{E} \tag{5.29}$$

$$\left[1-\Gamma_{FH}^{E}\left(\bar{\omega}_{FH,t+1}^{E}\right)\right] R_{FH,t+1}^{E} Q_{F,t} K_{FH,t} \geq R_{FH,t+1}^{E} NW_{F,t}^{E} \tag{5.30}$$

The expected payoff of the domestic financial intermediary from lending to home entrepreneurs is given by the loan repayment in the case the entrepreneur does not default and by the remaining payoff of the entrepreneurs minus monitoring costs in case the entrepreneur defaults:

$$\left\{\begin{array}{c} Z_{HH,t+1}^{E}\left(1-\tau_{H}^{E}\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^{E}\right)\left[\int_{\bar{\omega}_{HH,t+1}^{E}}^{\infty} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E}\right]+ \\ \left(1-\tau_{H}^{E}\right)R_{HH,t+1}^{E}Q_{H,t}K_{HH,t}\left[\left(1-\mu_{H}^{E}\right)\int_{0}^{\bar{\omega}_{HH,t+1}^{E}} \omega_{HH,t+1}^{E} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E}\right] \end{array}\right\} =$$

$$= \left(1-\tau_{H}^{E}\right)R_{HH,t+1}^{E}Q_{H,t}K_{HH,t}\left[\begin{array}{c} \bar{\omega}_{HH,t+1}^{E}\int_{\bar{\omega}_{HH,t+1}^{E}}^{\infty} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E}+ \\ \left(1-\mu_{H}^{E}\right)\int_{0}^{\bar{\omega}_{HH,t+1}^{E}} \omega_{HH,t+1}^{E} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E} \end{array}\right]$$

Denoting:

$$\begin{aligned} \Gamma_{HH}^{E}\left(\bar{\omega}_{HH,t+1}^{E}\right) &= \bar{\omega}_{HH,t+1}^{E}\left(1-\int_{0}^{\bar{\omega}_{HH,t+1}^{E}} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E}\right)+ \\ &\quad + \int_{0}^{\bar{\omega}_{HH,t+1}^{E}} \omega_{HH,t+1}^{E} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E} \\ G_{HH}^{E}\left(\bar{\omega}_{HH,t+1}^{E}\right) &= \int_{0}^{\bar{\omega}_{HH,t+1}^{E}} \omega_{HH,t+1}^{E} f(\omega_{HH,t+1}^{E})d\omega_{HH,t+1}^{E} \end{aligned}$$

Defining

probability of default, and $\int_0^{\bar{\omega}} \omega f(\omega)d\omega = E(\omega|\omega \leq \bar{\omega})$. Furthermore, recall that the payoff of defaulting entrepreneurs is zero.

$$\Phi^E\left(\bar{\omega}^E_{HH,t+1}\right) \equiv \Gamma^E_{HH}\left(\bar{\omega}^E_{HH,t+1}\right) - \mu^E_H G^E_H\left(\bar{\omega}^E_{HH,t+1}\right)$$

as the share of payoff of Home entrepreneurs borrowing from Home financial intermediaries that is captured by Home financial intermediaries, made of the share of expected payoff not retained by entrepreneurs ($\Gamma^E_{HH}\left(\bar{\omega}^E_{HH,t+1}\right)$) minus the expected monitoring cost the financial intermediary has to incur if the entrepreneur defaults ($\mu^E_H G^E_H\left(\bar{\omega}^E_{HH,t+1}\right)$), I can write more compactly[89]:

$$\left(1-\tau^E_H\right) R^E_{HH,t+1} Q_{H,t} K_{HH,t} \Phi^E\left(\bar{\omega}^E_{HH,t+1}\right) \tag{5.31}$$

The financial intermediary in the Home country will engage in the contracts with domestic and foreign entrepreneurs only when the payoff of doing so (e.g. the expected earnings of the loan portfolio) will at least be equal to the return the intermediary expects to receive, denoted R^F_{t+1}. Hence, the following participation constraint has to hold:

$$\begin{aligned}
& \left(1-\tau^E_H\right) R^E_{HH,t+1} Q_t K_{HH,t} \Phi\left(\bar{\omega}^E_{HH,t+1}\right) + \tau^E_F R^E_{FH,t+1} \frac{\varepsilon_{t+1}}{\varepsilon_t} Q_{F,t} K_{FH,t} \Phi\left(\bar{\omega}^E_{FH,t+1}\right) \\
= \; & R^F_{H,t+1}\left[\left(1-\tau^E_H\right)\left(Q_{H,t}K_{HH,t} - NW^E_{H,t}\right) + \tau^E_F \varepsilon_t \left(Q_{F,t}K_{FH,t} - NW^E_{F,t}\right)\right] \qquad (5.32)
\end{aligned}$$

Contract between financial intermediaries and international investors

The contract between financial intermediaries and lenders is similar to the one just described for entrepreneurs: only, in this case, the financial intermediary is the debtor party in the credit contract. Let us still consider the point of view of financial intermediaries in the Home country. Financial intermediaries are endowed with net worth $NW^F_{H,t}$ and stipulate credit contracts with domestic and foreign lenders (house-

89 Analogous expressions hold in the contract stipulated between Home financial intermediaries and Foreign entrepreneurs.

holds) in order to finance the part of their loan portfolio exceeding net worth. Given the amount of loans granted to home and foreign entrepreneurs, the domestic financial intermediary borrows $L^F_{H,t} = \begin{bmatrix} \left(1-\tau^E_H\right)\left(Q_{H,t}K_{HH,t} - NW^E_{H,t}\right) + \\ \tau^E_F \varepsilon_t \left(Q_{F,t}K_{FH,t} - NW^E_{F,t}\right) \end{bmatrix} - NW^F_{H,t}$. In particular, the financial intermediary uses a fraction $(1-\tau^F_H)$ of its net worth to borrow from domestic lenders and a fraction τ^F_H to borrow from foreign lenders, and uses profits from its loan portfolio to honor its debts. Each financial intermediary is subject to an idiosyncratic iid productivity shock $\omega^F_{ij,t+1}$, so that the effective return to its assets is given by $\omega^F_{ij,t+1} R^F_{i,t+1}$[90]. The financial intermediary stipulates two credit contracts, one with domestic and one with foreign lenders[91], which determine the contractual lending rate for domestic (foreign) borrowing $Z^F_{HH,t+1}$($Z^F_{HF,t+1}$) and the default thresholds $\bar{\omega}^F_{HH,t+1}$ ($\bar{\omega}^F_{HF,t+1}$):

$$\bar{\omega}^F_{HH,t+1} R^F_{H,t+1} \begin{bmatrix} \left(1-\tau^E_H\right)\left(Q_{H,t}K_{HH,t} - NW^E_{H,t}\right) + \\ +\tau^E_F \varepsilon_t \left(Q_{F,t}K_{FH,t} - NW^E_{F,t}\right) \end{bmatrix} = Z^F_{HH,t+1} L^F_{H,t} \tag{5.33}$$

$$\bar{\omega}^F_{HF,t+1} R^F_{H,t+1} \frac{1}{\varepsilon_{t+1}} \begin{bmatrix} \left(1-\tau^E_H\right)\left(Q_{H,t}K_{HH,t} - NW^E_{H,t}\right) + \\ +\tau^E_F \varepsilon_t \left(Q_{F,t}K_{FH,t} - NW^E_{F,t}\right) \end{bmatrix} = Z^F_{HF,t+1} L^F_{H,t} \tag{5.34}$$

Once again, if $\omega^F_{ij,t+1} \geq \bar{\omega}^F_{ij,t+1}$the financial intermediary does not default and keeps the profits after honoring its debt; if $\omega^F_{ij,t+1} < \bar{\omega}^F_{ij,t+1}$the financial intermediary goes bankrupt, and lenders incur a monitoring cost in order to seize the bank's remaining assets. The expected payoff of the financial intermediary from the debt contract can be expressed as:

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90 The stochastic shock is iid across financial intermediaries and time, and follows a log-normal distribution $\omega^F_{ij} \sim \log N(-\frac{\sigma^2_F}{2}, \sigma^2_F)$, where σ^2_F represents the variance of the underlying Normal distribution. In what follows, the density of the idiosyncratic shock is denoted as $f(\cdot)$ and its cumulative distribution as $F(\cdot)$. Foreign financial intermediaries are characterized by an idiosyncratic shock with the same characteristics.

91 As in te previous section, I use the subscript ij, $i, j = H, F$ to denote a financial intermediary in country i borrowing from lenders in country j.

$$\left\{ \begin{array}{c} (1-\tau_H^F)R_{H,t+1}^F \left[\left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right)\right]\cdot \\ \left[\int_{\bar{\omega}_{HH,t+1}^F}^{\infty}\omega_{HH,t+1}^F f(\omega_{HH,t+1}^F)d\omega_{HH,t+1}^F-\bar{\omega}_{HH,t+1}^F\int_{\bar{\omega}_{HH,t+1}^F}^{\infty}f(\omega_{HH,t+1}^F)d\omega_{HH,t+1}^F\right] \end{array} \right\}+$$
$$\left\{ \begin{array}{c} \tau_H^F R_{H,t+1}^F \left[\left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right)\right]\cdot \\ \left[\int_{\bar{\omega}_{HF,t+1}^F}^{\infty}\omega_{HF,t+1}^F f(\omega_{HF,t+1}^F)d\omega_{HF,t+1}^F-\bar{\omega}_{HF,t+1}^F\int_{\bar{\omega}_{HF,t+1}^F}^{\infty}f(\omega_{HF,t+1}^F)d\omega_{HF,t+1}^F\right] \end{array} \right\}$$

As in the previous case, lenders participate in the contract only if it is worthy to do so. In particular, lenders in each country require that lending funds to financial intermediaries yields an expected return at least equal to what they would obtain by investing funds in the risk-free asset. The participation constraints of domestic and foreign lenders in the contract with home financial intermediaries are respectively:

$$\begin{aligned} & (1-\tau_H^F)R_{H,t+1}^F \left\{ \begin{array}{c} \left[\begin{array}{c} \left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+ \\ +\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right) \end{array} \right]\cdot \\ \left[\Gamma^F\left(\bar{\omega}_{HH,t+1}^F\right)-\mu_{HH}^F G^F\left(\bar{\omega}_{HH,t+1}^F\right)\right] \end{array} \right\} \\ \geq \quad & R_t(1-\tau_H^F)\left[\begin{array}{c} \left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+ \\ +\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right)-NW_{H,t}^F \end{array} \right] \end{aligned} \tag{5.35}$$

$$\begin{aligned} & \tau_H^F R_{H,t+1}^F \left\{ \begin{array}{c} \left[\begin{array}{c} \left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+ \\ +\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right) \end{array} \right]\cdot \\ \left[\Gamma^F\left(\bar{\omega}_{HF,t+1}^F\right)-\mu_{HF}^F G^F\left(\bar{\omega}_{HF,t+1}^F\right)\right] \end{array} \right\} \\ \geq \quad & R_t^*\frac{\varepsilon_{t+1}}{\varepsilon_t}\tau_H^F\left[\begin{array}{c} \left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+ \\ +\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right)-NW_{H,t}^F \end{array} \right] \end{aligned} \tag{5.36}$$

It is important to notice that this setup implies that banks in each country are bearing the consequences of exchange rate movements on their balance sheets. In fact, entrepreneurs in each country borrow from Home and Foreign financial intermediaries in their own country's currency. Therefore, they are not subject to currency mismatch in their balance sheets. On the contrary, banks' balance sheets in each country are affected by the exchange rate. Consider for example banks in the Home country. They grant loans to Home entrepreneurs in the Home country's currency and loans to Foreign entrepreneurs in the Foreign country's currency. Furthermore, they receive funds from Home depositors (in the domestic currency) and from Foreign depositors in foreign currency. Therefore, an exchange rate depreciation has two effect on the balance sheet of Home country banks. On one side, it increases the (domestic currency) value of loans obtained from Foreign lenders, thereby increasing leverage. On the other side, it increases the value of loans granted to Foreign entrepreneurs, boosting the asset side of the balance sheet. These two effects act in opposite directions.

Optimal contract

The optimal contract is characterized by the levels of capital investment ($K_{HH,t}$ and $K_{FH,t}$), and the threshold values $\bar{\omega}^F_{HH,t+1}, \bar{\omega}^F_{HF,t+1}, \bar{\omega}^E_{HH,t+1}, \bar{\omega}^E_{FH,t+1}$ that maximize the financial intermediary' s payoff subject to the participation constraints of Home and Foreign lenders (5.36, 5.35) and of Home and Foreign entrepreneurs (5.29, 5.30).[92]

The first order conditions of the optimal contract resulting from the constrained maximization problem are:

[92] For computational details, refer to the Appendix.

$$0 = \left\{ \begin{array}{c} R^E_{HH,t+1} \left[\begin{array}{c} \left(1-\Gamma^E_{HH}\left(\omega^E_{HH,t+1}\right)\right)\Phi^{E\prime}\left(\omega^E_{HH,t+1}\right)+ \\ +\Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right)\Phi^E\left(\omega^E_{HH,t+1}\right) \end{array} \right] \cdot \\ \left[\left(1-\Gamma^F\left(\omega^F_{HH,t+1}\right)\right)(1-\tau^F_H)+\left(1-\Gamma^F\left(\omega^F_{HF,t+1}\right)\right)\tau^F_H\right] \end{array} \right\} + \tag{5.37}$$

$$+(1-\tau^F_H)\frac{\Gamma^{F\prime}\left(\omega^F_{HH,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HH,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right)\Phi^F\left(\omega^F_{HH,t+1}\right)R^E_{HH,t+1}\Phi^E\left(\omega^E_{HH,t+1}\right) \\ -R_t\Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right)+ \\ \Phi^F\left(\omega^F_{HH,t+1}\right)\Phi^{E\prime}\left(\omega^E_{HH,t+1}\right)\cdot \\ \left(1-\Gamma^E_H\left(\omega^E_{HH,t+1}\right)\right)R^E_{HH,t+1} \end{array} \right] +$$

$$+\tau^F_H\frac{\Gamma^{F\prime}\left(\omega^F_{HF,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HF,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{H,t+1}\right)\Phi^F\left(\omega^F_{HF,t+1}\right)R^E_{HH,t+1}\Phi^E\left(\omega^E_{HH,t+1}\right) \\ -R^*_t\frac{\varepsilon_{t+1}}{\varepsilon_t}\Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right)+ \\ \Phi^F\left(\omega^F_{HF,t+1}\right)\Phi^{E\prime}\left(\omega^E_{HH,t+1}\right)\cdot \\ \left(1-\Gamma^E_H\left(\omega^E_{HH,t+1}\right)\right)R^E_{HH,t+1} \end{array} \right]$$

$$0 = \left\{ \begin{array}{c} R^E_{FH,t+1} \left[\begin{array}{c} \left(1-\Gamma^E_H\left(\omega^E_{FH,t+1}\right)\right)\Phi^{E\prime}\left(\omega^E_{FH,t+1}\right)+ \\ +\Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right)\Phi^E\left(\omega^E_{FH,t+1}\right) \end{array} \right] \cdot \\ \left[\left(1-\Gamma^F\left(\omega^F_{HH,t+1}\right)\right)(1-\tau^F_H)+\left(1-\Gamma^F\left(\omega^F_{HF,t+1}\right)\right)\tau^F_H\right] \end{array} \right\} + \tag{5.38}$$

$$+(1-\tau^F_H)\frac{\Gamma^{F\prime}\left(\omega^F_{HH,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HH,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right)\Phi^F\left(\omega^F_{HH,t+1}\right)R^E_{FH,t+1}\Phi^E\left(\omega^E_{FH,t+1}\right)- \\ R_t\Gamma^{E\prime}_{FH}\left(\omega^E_{FH,t+1}\right)+ \\ \Phi^F\left(\omega^F_{HH,t+1}\right)\Phi^{E\prime}\left(\omega^E_{FH,t+1}\right)\cdot \\ \left(1-\Gamma^E_{FH}\left(\omega^E_{FH,t+1}\right)\right)R^E_{FH,t+1} \end{array} \right] +$$

$$+\tau^F_H\frac{\Gamma^{F\prime}\left(\omega^F_{HF,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HF,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right)\Phi^F\left(\omega^F_{HF,t+1}\right)R^E_{FH,t+1}\Phi^E\left(\omega^E_{FH,t+1}\right)- \\ R^*_t\frac{\varepsilon_{t+1}}{\varepsilon_t}\Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right)+ \\ \Phi^F\left(\omega^F_{HF,t+1}\right)\Phi^{E\prime}\left(\omega^E_{FH,t+1}\right)\cdot \\ \left(1-\Gamma^E_H\left(\omega^E_{FH,t+1}\right)\right)R^E_{FH,t+1} \end{array} \right]$$

$$(1-\tau^F_H)\Phi^F\left(\omega^F_{HH,t+1}\right)\cdot\left[\begin{array}{c} \left(1-\tau^E_H\right)R^E_{HH,t+1}Q_{H,t}K_{HH,t}\Phi^E\left(\omega^E_{HH,t+1}\right)+ \\ \tau^E_F R^E_{FH,t+1}\frac{\varepsilon_{t+1}}{\varepsilon_t}Q_{F,t}K_{FH,t}\Phi^E\left(\omega^E_{FH,t+1}\right) \end{array} \right] =$$
$$R_t(1-\tau^F_H)\left[\left(1-\tau^E_H\right)\left(Q_{H,t}K_{HH,t}-NW^E_{H,t}\right)+\tau^E_F\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW^E_{F,t}\right)-NW^F_{H,t}\right]$$

$$\tau^F_H\Phi^F\left(\omega^F_{HF,t+1}\right)\cdot\left[\begin{array}{c} \left(1-\tau^E_H\right)R^E_{HH,t+1}Q_{H,t}K_{HH,t}\Phi^E\left(\omega^E_{HH,t+1}\right)+ \\ \tau^E_F R^E_{FH,t+1}\frac{\varepsilon_{t+1}}{\varepsilon_t}Q^*_{F,t}K_{FH,t}\Phi^E\left(\omega^E_{FH,t+1}\right) \end{array} \right] =$$
$$R^*_t\frac{\varepsilon_{t+1}}{\varepsilon_t}\tau^F_H\left[\left(1-\tau^E_H\right)\left(Q_{H,t}K_{HH,t}-NW^E_{H,t}\right)+\tau^E_F\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW^E_{F,t}\right)-NW^F_{H,t}\right]$$

$$\left[1-\Gamma_{HH}^{E}\left(\omega_{HH,t+1}^{E}\right)\right]R_{HH,t+1}^{E}Q_{H,t}K_{HH,t}=R_{HH,t+1}^{E}NW_{H,t}^{E}$$

$$\left[1-\Gamma_{FH}^{E}\left(\omega_{FH,t+1}^{E}\right)\right]R_{FH,t+1}^{E}Q_{F,t}K_{FH,t}=R_{FH,t+1}^{E}NW_{F,t}^{E}$$

Net worth

As in BGG (1999) entrepreneurs and financial institutions have a finite life horizon. In particular, in each period the probability to exit the market is equal to $\left(1-\gamma^{E}\right)$ for entrepreneurs and $\left(1-\gamma^{F}\right)$ for financial institutions. The dying agents are immediately replaced by an equal number of newly born entrepreneurs and financial institutions, so that the population remains constant. This assumption ensures that borrowers do not accumulate enough net worth to become fully self-sufficient. Furthermore, both entrepreneurs and financial intermediaries receive payments, denoted respectively $W_{H,t}^{E}$ and $W_{H,t}^{F}$, for labor services supplied to firms in their country of origin[93]. Surviving agents accumulate net worth, which is made of the return from investment net of debt repayments plus the wage income they gain by working in intermediate goods producing firms. The dynamic evolution of net worth for entrepreneurs and financial institutions in the home country can be expressed as:

$$NW_{H,t}^{E} = \gamma^{E}V_{H,t}^{E}+W_{H,t}^{E} \tag{5.39}$$

$$NW_{H,tt}^{F} = \gamma^{F}V_{H,t}^{F}+W_{H,t}^{F} \tag{5.40}$$

Where $V_{H,t}^{E}$ and $V_{H,t}^{F}$represent the equity of entrepreneurs and financial intermediaries respectively:

[93] The presence of wages guarantees that net worth is non-zero in steady state, but does not have a significant effect on the dynamics of net worth given the small share of entrepreneurs' and bankers' labor in the production function.

$$
\begin{aligned}
V^E_{H,t} &= \left[1-\Gamma^E_{HH,t-1}\left(\bar{\omega}^E_{HH,t}\right)\right]\left(1-\tau^E_H\right)R^E_{HH,t}Q_{H,t-1}K_{HH,t-1}+ \\
&\quad +\left[1-\Gamma^E_{HF,t-1}\left(\bar{\omega}^E_{HF,t}\right)\right]\tau^E_H R^E_{HF,t}Q_{H,t-1}K_{HF,t-1}
\end{aligned} \tag{5.41}
$$

$$
\begin{aligned}
V^F_{H,t} &= \left[1-\Gamma^F_{HH,t-1}\left(\bar{\omega}^F_{HH,t}\right)\right]\left(1-\tau^F_H\right)R^F_{Ht}\left\{\begin{array}{c}\left(1-\tau^E_H\right)\left(Q_{H,t-1}K_{HH,t-1}-NW^E_{H,t-1}\right)\\ +\tau^E_F\varepsilon_{t-1}\left(Q_{F,t-1}K_{FH,t-1}-NW^E_{F,t-1}\right)\end{array}\right\}+ \\
&\quad +\left[1-\Gamma^F_{HF,t-1}\left(\bar{\omega}^F_{HF,t}\right)\right]\tau^F_H R^F_{H,t}\left\{\begin{array}{c}\left(1-\tau^E_H\right)\left(Q_{H,t-1}K_{HH,t-1}-NW^E_{H,t-1}\right)\\ +\tau^E_F\varepsilon_{t-1}\left(Q_{F,t-1}K_{FH,t-1}-NW^E_{F,t-1}\right)\end{array}\right\}
\end{aligned} \tag{5.42}
$$

Hence, $V^E_{H,t}$ represents the retained earnings of the domestic entrepreneurial sector, derived from their capital investment using funds from domestic and foreign financial institutions. $V^F_{H,t}$ represents retained earnings of financial institutions on their portfolio of loans to domestic and foreign entrepreneurs. Agents leaving the market at any time period consume the entire value of their assets, hence consumption of entrepreneurs and financial intermediaries is given by:

$$
C^E_{H,t} = \left(1-\gamma^E\right)V^E_{H,t} \tag{5.43}
$$

$$
C^F_{H,t} = \left(1-\gamma^F\right)V^F_{H,t} \tag{5.44}
$$

And it has the same composition as households' consumption.

5.1.6 Exchange rate and terms of trade

Prices in the tradable sector are set in the producers' currency. Furthermore, it is assumed that the international law of one price holds, implying that the price of the same good sold in the two countries is equalized using the nominal exchange rate S_t (defined as the price of foreign currency in terms of domestic currency). This implies that:

$$
P^*_{H,t} = \frac{1}{S_t}P_{H,t} \text{ and } P_{F,t} = S_t P^*_{F,t} \tag{5.45}
$$

I define the real exchange rate:

$$\varepsilon_t = \frac{S_t P_t^*}{P_t} \tag{5.46}$$

I define the terms of trade as the ratio between import and export prices in domestic currency, which, given the law of one price, can be expressed as:

$$TOT_t = \frac{S_t P_{F,t}^*}{P_{H,t}} \tag{5.47}$$

Monetary and fiscal policy

Monetary policy sets the short-term interest rate in both economies, according to endogenous economic developments. The central bank in the Home country sets the short-term nominal interest rate according to a rule of the following general form:

$$\frac{R_t^n}{R^n} = \left(\frac{R_{t-1}^n}{R^n}\right)^{\rho_r} \left[\left(\frac{\pi_{H,t}}{\pi_H}\right)^{\rho_\pi} \left(\frac{Y_{H,t}}{Y_H}\right)^{\rho_y} \left(\frac{S_t}{S}\right)^{\rho_S}\right]^{(1-\rho_r)} \exp(\xi_{R,t}) \tag{5.48}$$

Where variables without time subscript refer to steady state values. In particular, for $\rho_S = 0$ the Home country implements a floating exchange rate regime. On the other hand, it follows a fixed exchange rate by setting ρ_S so large that $R_t = R_t^*$. $\xi_{R,t}$ represents an exogenous monetary policy shock.

The Foreign country's monetary policy sets the policy rate according to the following feedback rule:

$$\frac{R_t^{n*}}{R^{n*}} = \left(\frac{R_{t-1}^{n*}}{R^{n*}}\right)^{\rho_r^*} \left[\left(\frac{\pi_{F,t}}{\pi_F}\right)^{\rho_\pi^*} \left(\frac{Y_{F,t}}{Y_F}\right)^{\rho_y^*}\right]^{(1-\rho_r)} \exp(\xi_{R^*,t}) \tag{5.49}$$

The fiscal authority aims at attaining a balanced budget in every period:

$$G_t = T_t \tag{5.50}$$

5.1.7 Market clearing and equilibrium

Market clearing in each country requires that total production equals total absorption. In particular, domestic output is used for home consumption, home investment, government expenditure and exports. Furthermore, a small fraction of output is lost in each period due to monitoring costs incurred by lenders and financial institutions. The total amount of monitoring costs is given by the following equation:

$$
\begin{aligned}
M_t = {} & \mu^E G^E\left(\bar{\omega}^E_{HH,t}\right) R^E_{HH,t}\left(1-\tau^E_H\right) Q_{H,t-1}K_{HH,t-1} + \\
& + \mu^E G^E\left(\bar{\omega}^E_{FH,t}\right) R^E_{FH,t}\varepsilon_{t-1}\tau^E_F Q_{F,t-1}K_{FH,t-1} + \\
& + \mu^F G^F\left(\bar{\omega}^F_{HH,t}\right) R^F_{Ht}\left(1-\tau^F_H\right)\left[\begin{array}{c} \left(1-\tau^E_H\right)\left(Q_{H,t-1}K_{HH,t-1}-NW^E_{H,t-1}\right) + \\ \tau^E_F\varepsilon_{t-1}\left(Q_{F,t-1}K_{FH,t-1}-NW^E_{F,t-1}\right)\end{array}\right] + \\
& + \mu^F G^F\left(\bar{\omega}^F_{FH,t}\right)\tau^F_F\varepsilon_{t-1}R^F_{FH,t}\left[\begin{array}{c} \frac{1}{\varepsilon_{t-1}}\tau^E_H\left(Q_{H,t-1}K_{HF,t-1}-NW^E_{H,t-1}\right) + \\ \left(1-\tau^E_F\right)\left(Q^*_{F,t-1}K^*_{FF,t-1}-NW^E_{F,t-1}\right)\end{array}\right]
\end{aligned}
$$

Where the first two terms on the right-hand side represent monitoring costs incurred by Home financial intermediaries involved in credit contracts with Home and Foreign entrepreneurs, and the last two terms represent the cost incurred by domestic lenders in the contracts with Home and foreign financial intermediaries.

The Home country's resource constraint can then be written as[94]:

[94] The resource constraint in the Home country and its Foreign counterpart hilight the implications of the small open economy assumption. Specifically, substituting equations (5.4) and (5.5) and their Foreign counterparts in the resource constraints of the Home and Foreign country, we obtain:

$$
\begin{aligned}
Y_{H,t} &= \left[\begin{array}{c} \Delta_{H,t}\left(G_t+M_t\right)+\Delta_{H,t}\left(1-\left(1-n\right)\lambda\right)\left(\frac{P_{H,t}}{P_t}\right)^{-1}\left(C_t+C^E_t+C^F_t+I_t\right) + \\ +\Delta^*_{H,t}\frac{(1-n)}{n}n\lambda\left(\frac{P^*_{H,t}}{P^*_t}\right)^{-1}\left(C^*_t+C^{E*}_t+C^{F*}_t+I^*_t\right)\end{array}\right] \\
Y^*_t &= \left[\begin{array}{c} \Delta^*_{F,t}\left(G^*_t+M^*_t\right)+\Delta^*_{F,t}(1-n\lambda)\left(\frac{P^*_{F,t}}{P^*_t}\right)^{-1}\left(C^*_t+C^{E*}_t+C^{F*}_t+I^*_t\right) + \\ +\Delta^*_{F,t}\frac{n}{(1-n)}\left(\left(1-n\right)\lambda\right)\left(\frac{P_{F,t}}{P_t}\right)^{-1}\left(C_t+C^E_t+C^F_t+I_t\right)\end{array}\right]
\end{aligned}
\tag{5.51}
$$

Letting $n \to 0$:

$$Y_{H,t} = \Delta_{H,t}\left(C_{H,t} + C^{E}_{H,t} + C^{F}_{H,t} + I_{H,t} + G_t + M_t\right) + \Delta^{*}_{H,t}\frac{(1-n)}{n}\left(C^{*}_{H,t} + C^{E*}_{H,t} + C^{F*}_{H,t} + I^{*}_{H,t}\right) \tag{5.52}$$

Where $\Delta_{H,t}$ and $\Delta^{*}_{H,t}$ are indexes of price dispersion implied by the staggered price setting defined as:

$$\begin{aligned} \Delta_{H,t} &= \int_0^1 \left(\frac{P_t(j_H)}{P_t}\right)^{-\phi_H} dj_H \\ \Delta^{*}_{H,t} &= \int_0^1 \left(\frac{P^{*}_{H,t}(j_H)}{P^{*}_t}\right)^{-\phi_H} dj_H \end{aligned}$$

and whose laws of motion are given by:

$$\Delta_{H,t} = (1-\theta_H)\left[\frac{1-\theta_H\left(\frac{1}{\pi_{H,t}}\right)^{1-\varepsilon_H}}{1-\theta_H}\right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}} + \theta_H\left(\frac{1}{\pi_{H,t}}\right)^{-\varepsilon_H}\Delta_{H,t-1} \tag{5.53}$$

$$\Delta^{*}_{H,t} = (1-\theta_H)\left[\frac{1-\theta_H\left(\frac{1}{\pi^{*}_{H,t}}\right)^{1-\varepsilon_H}}{1-\theta_H}\right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}} + \theta_H\left(\frac{1}{\pi^{*}_{H,t}}\right)^{-\varepsilon_H}\Delta^{*}_{H,t-1} \tag{5.54}$$

Market clearing in the labor market requires that total labor supply equals demand, a condition represented by equation (5.7). Furthermore, for the capital market

---

$$\begin{aligned} Y_t &= \Delta_{H,t}(G_t + M_t) + \Delta_{H,t}(1-\lambda)\left(\frac{P_{H,t}}{P_t}\right)^{-1}\left(C_t + C^{E}_t + C^{F}_t + I_t\right) + \\ &\quad + \Delta^{*}_{H,t}\lambda\left(\frac{P^{*}_{H,t}}{P^{*}_t}\right)^{-1}\left(C^{*}_t + C^{E*}_t + C^{F*}_t + I^{*}_t\right) \\ Y^{*}_t &= \Delta^{*}_{F,t}(G^{*}_t + M^{*}_t) + \Delta^{*}_{F,t}\left(\frac{P^{*}_{F,t}}{P^{*}_t}\right)^{-1}\left(C^{*}_t + C^{E*}_t + C^{F*}_t + I^{*}_t\right) \end{aligned}$$

The demand for Home country output depends on Foreign demand of Home goods, but not viceversa. Thi implies that any shock that impacts demand for Home goods in the Foreign country will have an impact in the Home country through demand effects. But the reverse is not true: demand shifts in the Home country have no influence on the demand for Foreign goods.

to be in equilibrium, the total capital investment by entrepreneurs (borrowing domestically and abroad) has to equal the aggregate capital production, i.e.:

$$K_t = \left(1 - \tau_H^E\right) K_{HH,t} + \tau_H^E K_{HF,t} \tag{5.55}$$

5.1.8 Steady state and calibration

Before simulating the model, I calculate the deterministic steady state by solving the linear system of static equations implied by the model (cfr. Appendix).

Table 5.1: Calibrated Parameters

Parameter	Value	Parameter	Value
φ	1	n	→0
σ	1	h	0.5
β	0.99	χ_H	
λ	0.4	α	0.35
ω_E	0.01	ω_F	0.01
δ	0.025	κ	2.5
θ_H	0.75	θ_w	0.94
ϵ	6	ϵ_w	10
$\mu_{E,H}$	0.033123	$\mu_{E,F}$	0.033123
$\mu_{F,H}$	0.243046	$\mu_{F,F}$	0.243046
γ_p	0.2	γ_E	0.98517
γ_F	0.96918		

The model parameters are calibrated following the literature. Concerning households' preferences, I set the intertemporal discount factor (β) to 0.99, which corresponds to a yearly risk-free interest rate of 4%. The intertemporal elasticity of substitution (σ) is set to 1, so as the elasticity of labor supply (φ) following Christiano, Eichenbaum, and Evans (1997). In order to obtain a steady state labor supply of 0.33 the coefficient on labor in the utility function (χ_H) is calibrated to 9.02. Regarding the composition of consumption, I set the share of imported goods in the consumption basket at 0.4, which implies a degree of home bias and the consumption habit parameter at 0.5. Finally, note that the Cobb-Douglas specification of the consumption aggregator implies unit elasticity of substitution between domestic and foreign goods.[95]

On the production side, the rate of depreciation of capital (δ) is set to 0.025, implying a yearly depreciation rate of 10%. Furthermore, I set the adjustment cost parameter, κ, to 2.5. The parameters of the production function are chosen such that the share of capital in production is 0.35, while the shares of labor by entrepreneurs and financial intermediaries (Ω^E and Ω^F respectively) is 0.01. Following the standard estimate used in the literature (Chari, Kehoe and McGratten (2000)), I assume a Calvo price stickiness parameter θ_H equal to 0.75, implying that price adjustment happens, on average, every four quarters. Furthermore, I assume that firms that do not optimally chose their price in a given period adjust their price to past inflation with a coefficient of 0.2. Finally, the elasticity of substitution between varieties of domestic goods (ϵ) is set to 6, implying a 20% price markup. The parameters of the wage setting process imply a higher persistence of wages compared to prices. I set the parameter representing the elasticity of substitution between labor types(ϵ_w) at 10, implying a 11% markup and the wage stickiness parameter (θ_w) equal to 0.94 (Schmitt-Grohé and Uribe (2006)).

The parameters pertaining to financial frictions in the banking and entrepreneurial sector are calibrated in order for the steady state values of key financial variables in the model to match time series data relative to Europe for the financial and non-financial sector. In particular, the parameters related to the cost of monitoring banks' and entrepreneurial output (μ^F and μ^E respectively), the volatility parameters of banks' and entrepreneurs' idiosyncratic productivity (σ^F and σ^E) and the survival probabilities (γ^E and γ^F) are calibrated in order to match European data on leverage, lending spreads and default probabilities. European data on bank default reveal that

95 For a similar specification see for example Kolasa and Lombardo (2011).

the expected short-term (1 year) default probability of banks averaged 0.6% between 2000 and 2007 (Fiordelisi et al. (2010)): hence I set the quarterly default probability of financial intermediaries to 0.0015. Following Faia (2010), I set the annual steady state default of entrepreneurs to 3%, implying a quarterly value of 0.0075. Steady state equity-to-assets ratios for entrepreneurs and banks are calibrated according to the micro-level data reported in Kalemli-Ozcan et al. (2011). In particular, I set the inverse leverage ratios to 0.4904 and 0.1040 for entrepreneurs and banks respectively, implying leverage ratios of 2.0939 and 9.6129. Finally, I calibrate the entrepreneurial and financial intermediaries' lending spreads according to Eurostat data on European interest rates between 2000 and 2007. Hence I target the steady state level of the spread between the lending rates of entrepreneurs and banks at 0.0052 quarterly, and the spread between financial intermediaries' lending rate and the risk free rate at 0.0003 quarterly. The calibrated values of the model parameters are reported in Table 5.1, while Table 5.2 reports the key steady state values resulting from the calibration.

Table 5.2: Steady State

R	1.0101
C/Y	0.5382
I/Y	0.1821
G/Y	0.2
H	0.33
QK/NW_e	0.4904
QK/NW_f	0.1040
R^k/R	1.0049
$Z^E - R$	0.0056
$Z^E - Z^F$	0.0052
$Z^F - R$	0.0004
$F(\bar{\omega_E})$	0.0075
$F(\bar{\omega_F})$	0.0015

The shocks considered involve the foreign interest rate R^*, foreign technology A^*, and the shocks to the variance of the odiosyncratic productivity of banks and entrepreneurs in the Foreign country, σ^{E*} and σ^{F*}. Shocks are modeled as (log) AR(1) processes with autoregressive parameter set at 0.85, with the exception of the Foreign interest rate shock, which is white noise. The size of shocks is 1% standard deviation in all cases.

The form of the interest rule allows for a variety of different types of monetary policy strategies of the small open economy. Table 5.3 reports the two different rules I am considering in the analysis, together with the parameters of the Taylor rule of the foreign economy, and the values of the parameters referring to the extent of international lending used in the model simulations[96].

Table 5.3: Overview of alternative models

No cross-border borrowing	$\tau_E = 0$	$\tau_F = 0$		
Banks' cross-border borrowing	$\tau_E = 0$	$\tau_F = 0.2$		
Full cross-border borrowing	$\tau_E = 0.2$	$\tau_F = 0.2$		
Monetary policy F	$\rho_r = 0.8$	$\rho_\pi = 1.5$	$\rho_y = 0$	
Monetary policy H				
Fixed exchange rate	$\rho_r = 0.8$	$\rho_\pi = 1.5$	$\rho_y = 0$	$\rho_S \rightarrow \infty$
Flexible exchange rate	$\rho_r = 0.8$	$\rho_\pi = 1.5$	$\rho_y = 0$	$\rho_S = 0$

5.2 Impulse response analysis

In this section I present the simulated path of the main real and financial variables of the small open economy in response to nominal, real and financial shocks. The small open economy emerges as a limit, when the relative size of the Home country,

[96] While in principle a standard Taylor rule reacting to output could be considered for the two countries, the choice of constraining coefficients and to zero is dictated by the desire to enhance the comparability of results in the current setting with those of Faia (2010), who examines the implications of fixed and flexible exchange rate regimes in a two country model without cross-border borrowing and lending.

n, tends to zero[97]. Hence, the Foreign country becomes relatively closed, but as long as there is a positive degree of openness, the Home economy continues to consume foreign produced goods. This allows to model the small open economy in a consistent way, retaining its trade and financial linkages with the rest of the world.

In figures 5.1 to 5.8, the responses for the Home country are presented for different exchange rate regimes and degrees of cross-border lending[98]. In particular, in the case of no international lending the coefficients $\tau^F_{HH}, \tau^F_{HF}, \tau^F_{FF}, \tau^F_{FH}, \tau^E_{HH}, \tau^E_{HF}, \tau^E_{FH}, \tau^E_{FF}$ are set to zero; in the case of cross-border bank borrowing only, i.e. a situation where banks can borrow from domestic and foreign lenders but entrepreneurs are constrained to borrow from banks in their own country, I set $\tau^F_{HH} = \tau^F_{HF} = \tau^F_{FF} = \tau^F_{FH} = 0.2$ and $\tau^E_{HH} = \tau^E_{HF} = \tau^E_{FH} = \tau^E_{FF} = 0$; finally, full cross-country lending implies fully blown lending relationships between banks, entrepreneurs and lenders in both countries (I set $\tau^E_{HH} = \tau^E_{HF} = \tau^E_{FH} = \tau^E_{FF} = 0.2$ and $\tau^F_{HH} = \tau^F_{HF} = \tau^F_{FF} = \tau^F_{FH} = 0.2$).

5.2.1 Foreign interest rate shock

Figures **(**5.1**)** and **(**5.2**)** depict the impulse responses corresponding to a monetary policy shock in the Foreign economy, for different exchange rate regimes (flexible and fixed, respectively) in the Home country and different degrees of cross-border lending.[99]

If the Home currency is allowed to float, the one percent standard deviation shock to the Foreign interest rate causes the nominal exchange rate to increase on impact, driving also the real exchange rate upwards, implying a real depreciation of the domestic currency. By making foreign goods relatively more expensive, the real

[97] For a similar approach, see Batini et al. (2007), De Paoli (2009) and Corsetti and Müller (2011).

[98] For space reasons, the responses of the main foreign variables are presented in the Appendix.

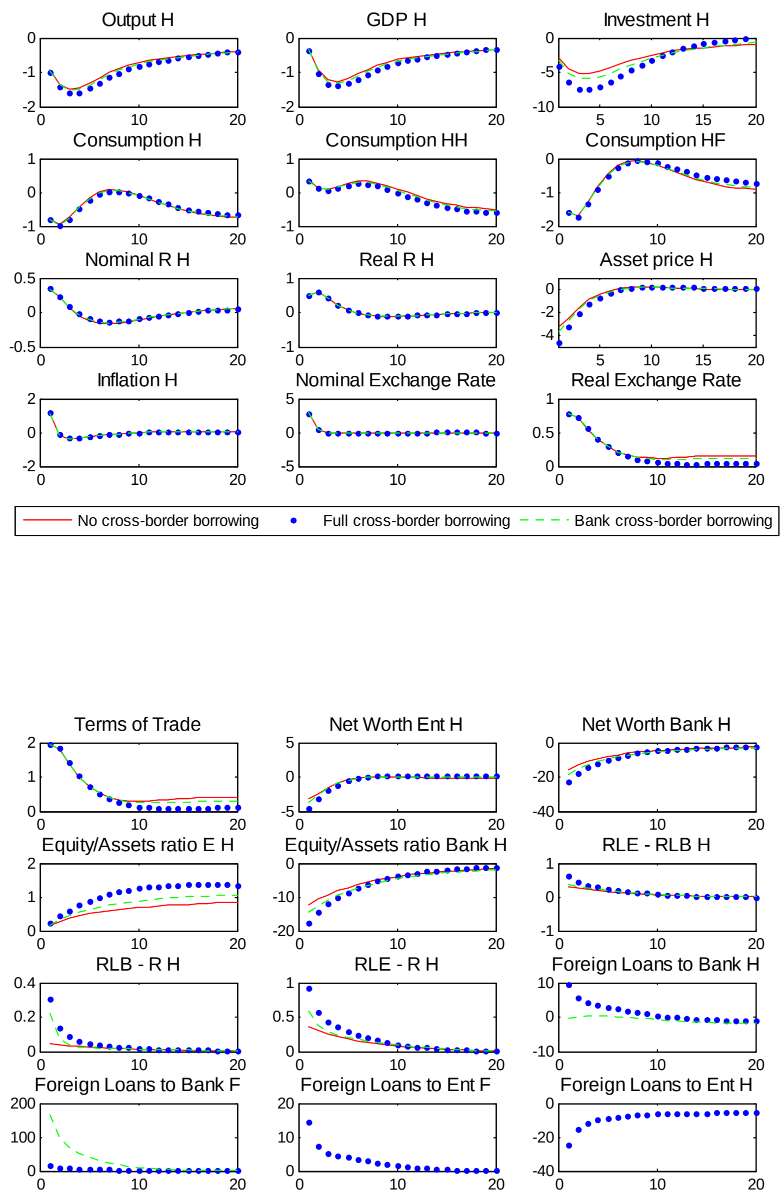
[99] The response of a set of Foreign country variables are presented in figure (5.9) in the Appendix.

depreciation has two effects. First, it drives an expenditure-switching effect towards domestic goods. Secondly, it contributes to the rise in inflation in the Home economy.

The increase in inflation, independently of the strength of financial linkages, leads the Home central bank to increase the nominal interest rate, which results in a real interest rate hike that depresses consumption, investment and output.

However, the negative effect on investment is more pronounced the greater the extent of international lending relationships. While in the case of domestic borrowing and lending only the financial sector is influenced by the foreign shock only to the extent that this implies a contractionary monetary policy response of the Home central bank, in the presence of financial linkages, the Domestic and Foreign interest rate hikes reinforce each other. In fact, as the risk free return of domestic and foreign lenders increase, the cost of external finance for domestic and foreign banks increases more markedly and it is reflected in a sharper increase in loan rates for financial intermediaries. As these are passed on to final borrowers, entrepreneurs' loan rates and borrowing spreads increase in both countries. As borrowing costs increase, entrepreneurs undertake fewer projects, thereby reducing investment, the demand for capital and hence asset prices by a larger amount. The combination of declining asset prices and higher borrowing costs decrease the net worth of entrepreneurs and banks worldwide. Figure (5.1) clearly shows that the decrease in entrepreneurial and banks' net worth, the increase in lending spreads and the consequent decrease in investment and asset prices are more pronounced with tighter internatioal lending relationships. The reason for this is twofold. First, when cross-border borrowing by entrepreneurs is shut off and only banks can borrow from abroad the foreign interest rate shock and the consequent domestic interest rate increase lead to an rise in the loan rate charged by Home banks on domestic entrepreneurs which is higher than in the case of financial autarky. Indeed, in the latter case the foreign monetary policy shock impacts the

Figure 5.1: Responses of Home country to a 0.01 foreign interest rate shock: Flexible exchange rate

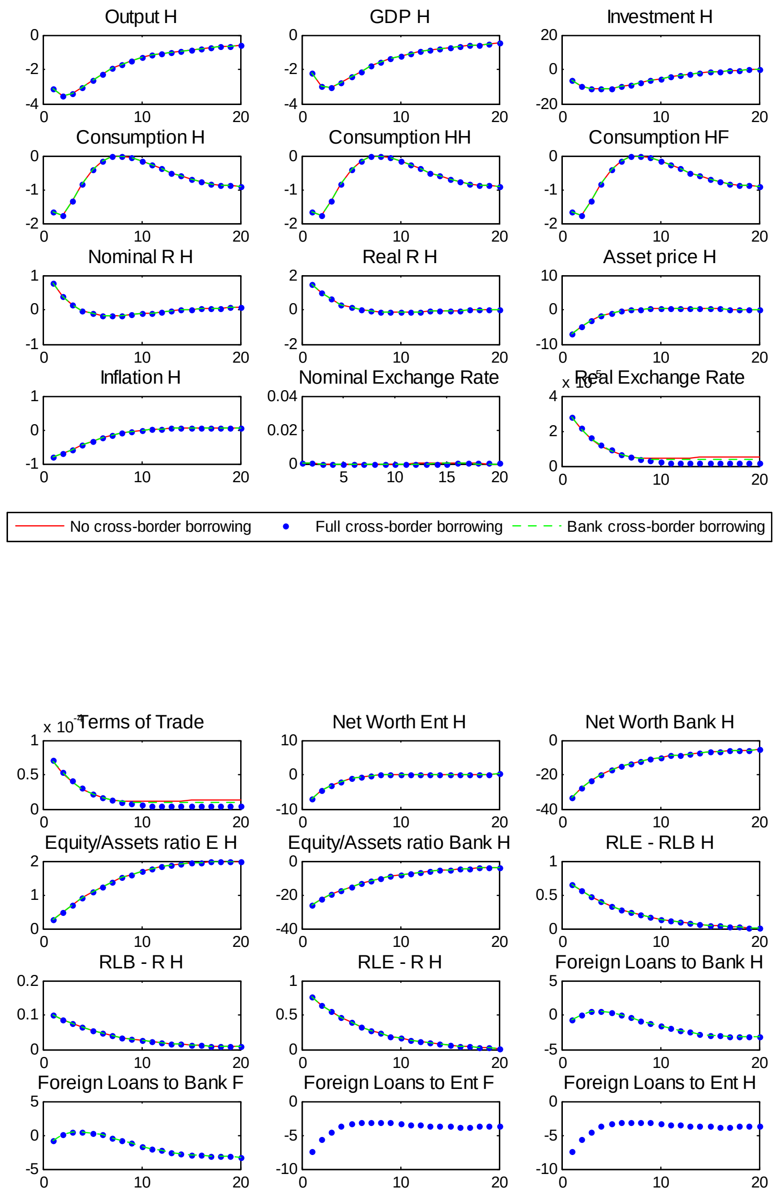


Note: Responses are represented in percentage deviations from the steady state

domestic financial sector only through the domestic monetary policy response. In the case cross-border borrowing also involves entrepreneurs, not only the foreign policy rate matters for the cost of funds of domestic banks, but the deterioration in entrepreneurial net worth in the Foreign country impacts domestic banks negatively affecting their net worth and leverage. Second, the real exchange rate depreciation increases the value of foreign loans held by banks in the Home country. The combination of these effects amplifies the effect of the foreign shock on the domestic economy.

In case the Home country follows a fixed exchange rate (cfr Figure (5.2)), the decline of both real and financial variables is more pronounced. This is due to the fact that, following the initial shock, the central bank in the home country increases its policy rate on impact to defend the currency. In fact, the nominal interest rate increase necessary to keep the exchange rate stable is of the same magnitude of the initial foreign shock, implying that the Home country is fully importing the foreign shock. As the nominal exchange rate is fixed and Home and Foreign inflation decline by the same amount, the real exchange rate is roughly constant. This eliminates, on the real side, expenditure switching effects and, on the financial side, balance sheet effects due to currency denomination of loans. The steeper increase in the real interest rate under a fixed exchange rate regime depresses consumption by a larger amount. Furthermore, the constancy of the real exchange rate implies that consumers demand less of both domestic and imported goods. The sharper decrease in consumption leads to a more pronounced decrease in demand for domestic goods, leading to a larger output drop and a lower demand for capital investment. Hence, output, investment and asset prices are lower than in the flexible exchange rate regime case. On the financial side, it is interesting to notice that a fixed exchange rate neutralizes differences across degrees of cross-border linkages. On one hand, in response to the foreign monetary policy shock, the domestic central bank increases the nominal interest rate to defend the parity roughly by the same magnitude, thereby "importing"

Figure 5.2: Responses of Home country to a 0.01 foreign interest rate shock: Fixed exchange rate



Note: Responses are represented in percentage deviations from the steady state

the foreign shock. On the other hand, in this model financial exposures across countries are symmetric. The joint effect of symmetric cross-country financial exposures, a de-facto symmetric shock and a fixed exchange rate lead the response of domestic and foreign variables to be parallel.

Table 5.4: Theoretical variances - Foreign interest rate shock

	No cross-border borrowing		Bank cross-border borrowing		Full cross-border borrowing	
	Float	Fix	Float	Fix	Float	Fix
Output	4.12	8.73	4.28	8.73	4.47	8.73
Investment	14.13	30.44	15.98	30.44	19.20	30.44
Consumption	3.77	5.02	3.66	5.02	3.46	5.02
Int.Rate	0.62	1.02	0.61	1.02	0.58	1.02
Asset Price	4.53	9.35	5.05	9.35	6.30	9.35
Inflation	1.32	1.40	1.31	1.40	1.31	1.40
Leverage E	8.60	17.82	10.39	17.82	12.14	17.82
Leverage B	27.69	58.81	32.65	58.81	33.58	58.81
Spread E	0.67	1.42	0.88	1.42	1.33	1.42

Note: In pecentage points

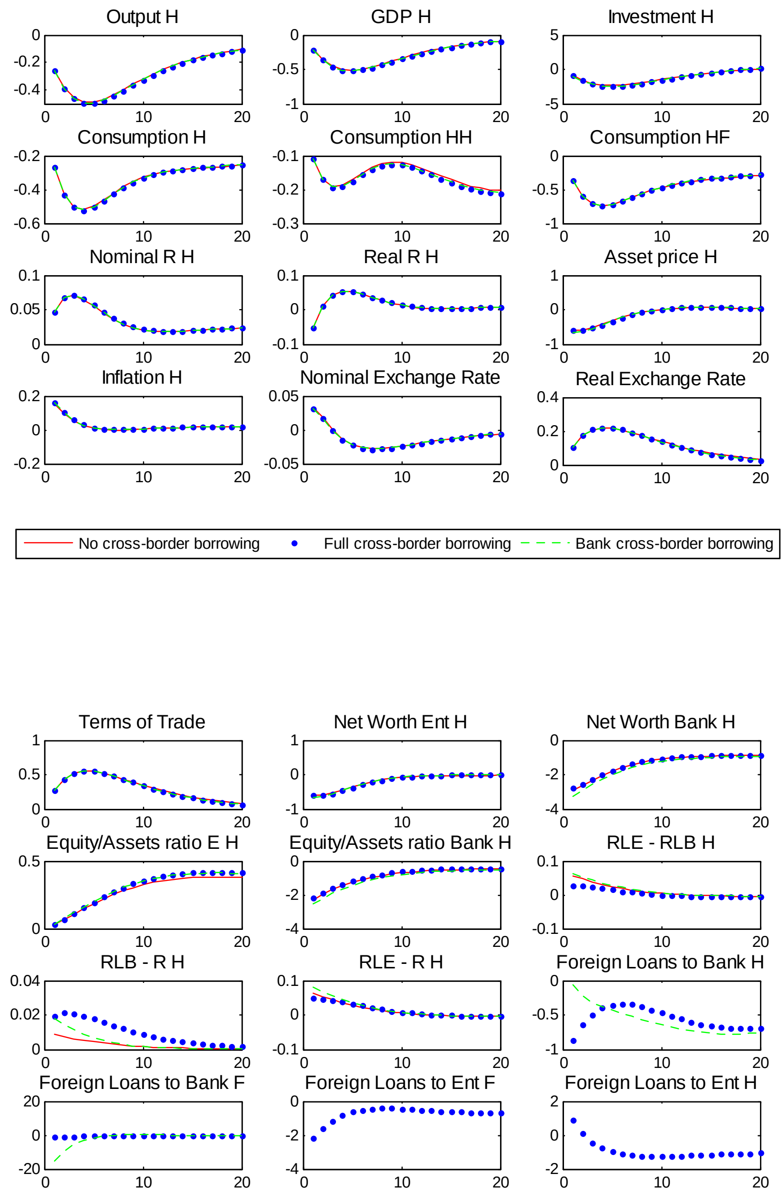
Table 5.4 reports theoretical variances for the main real and financial variables under fixed and flexible exchange rate regimes and different degrees of cross-border borrowing following a foreign interest rate shock. Comparing exchange rate regimes, it is evident that volatility in the domestic economy is much higher when the central bank follows a strict peg: in particular, output is twice as volatile compared to the case in which the currency is allowed to float, as well as investment and consumption. This is the result of the much stronger monetary policy response to the shock necessary to stabilize the exchange rate, which is reflected in the high standard deviation of the nominal interest rate. Furthermore, volatility increases with the degree of financial linkages. Under a floating exchange rate regime, financial variables are particularly more volatile when both financial intermediaries and entrepreneurs engage in cross-border borrowing, thanks to the immediate transmission of the foreign shock to the domestic economy via the financial sector and the direct spillover from balance sheets of foreign entrepreneurs. However, the degree of international borrowing is virtually irrelevant when the small country follows a strict peg, as the impulse-response functions previously revealed.

5.2.2 Foreign productivity shock

Figures (5.3) and (5.4), illustrate the reaction of the main Home country variables in response to a foreign productivity shock. In the foreign country (cfr Figure (5.10) in the Appendix), the negative productivity shock raises marginal costs, which in turn decrease production. This has two consequences: on one side, inflation increases; on the other side, demand for capital decreases, pushing its price downwards. The increase in inflation in the foreign country leads the foreign central bank to increase the nominal interest rate.

This, jointly with the decrease in asset prices, deteriorates balance sheet conditions of borrowers in the foreign country: both entrepreneurial and banks' net worth decrease in the foreign country, leading to an increase in borrowing spreads for both agents. Furthermore, the contractionary Foreign monetary policy depreciates the exchange rate, albeit by a small amount. The increase in Foreign inflation appreciates the foreign currency in real terms, and improves the terms of trade for the Home country. However, as the Home country is relatively small and open, the real depreciation pushes up domestic CPI inflation, which leads the domestic central bank to raise the nominal interest rate. In case the Home country follows a pegged exchange rate policy, the domestic central bank increases the nominal interest rate in order to counteract the nominal depreciation. In this case, the increase in domestic CPI inflation is more muted, so as the extent of real exchange rate depreciation and the required monetary policy contraction is stronger than in the case of flexible exchange rate. While in the first periods the increase in inflation dominates in driving

Figure 5.3: Responses of Home country to a 0.01 foreign productivity shock: Flexible exchange rate

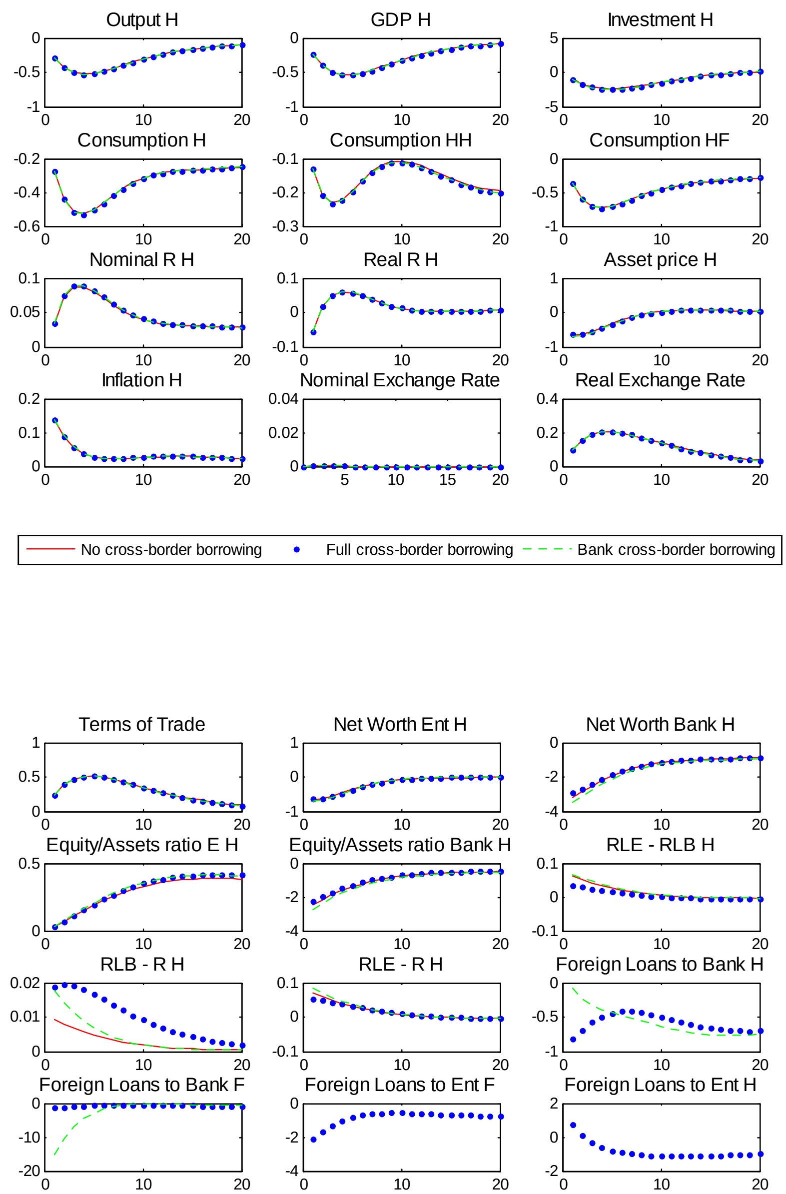


Note: Responses are represented in percentage deviations from the steady state

the real interest rate down, after few periods the real interest rate starts increasing, thereby determining a decrease in domestic consumption and a tightening of borrowing conditions for domestic banks. In particular, the real interest rate increases more sharply when the Home country's monetary policy pegs the exchange rate, leading to a sharper decrease in consumption, investment and GDP.

While the negative effect of the foreign productivity shock on the domestic economy is stronger when the Home country's central bank adopts a fixed exchange rate regime, the difference in responses between different degrees of financial linkages is more muted. Under domestic borrowing only, the financial sector is affected by the foreign productivity shock through two channels. First, the decrease in demand for capital by domestic firms that reduces the demand for investment and loans, thereby reducing leverage in the domestic financial sector and dampening the financial accelerator effect. Second, the increase in the domestic interest rate that increases the cost of funds for domestic financial intermediaries, accentuating the financial accelerator effect. Hence, the foreign shock is transmitted first to the real economy through a change in international relative prices and its effects on domestic CPI inflation, and then to the credit market through leverage and cost of funds effects. In case of bank cross-border borrowing, the financial accelerator effect is reinforced by the foreign monetary policy contraction that follows the adverse productivity shock. As the foreign interest rate hike is stronger than the domestic one, the cost of foreign borrowing increases by more than in the case of financial autarky. Furthermore, the real exchange rate depreciation acts in the same direction, feeding the financial accelerator effect and resulting in a sharper decrease in net worth and increase in borrowing spreads. In case of full international lending, the increase in financial acceleration caused by the foreign monetary policy contraction and real exchange rate depreciation is somewhat counteracted and the responses look similar to those obtained when cross-border borrowing is absent. This is due to the fact that the ex-

Figure 5.4: Responses of Home country to a 0.01 foreign productivity shock: Fixed exchange rate



Note: Responses are represented in percentage deviations from the steady state

change rate depreciation exerts a double effect on banks' balance sheets. On one side, it increases the loan burden (in domestic currency units) to be repaid to foreign lenders. On the other hand, it boosts banks' asset side by increasing the value of assets, i.e. loans granted to Foreign entrepreneurs. These effects act in opposite directions and completely offset each other.

Table 5.5: Theoretical variances - Foreign productivity shock

	No cross-border borrowing		Bank cross-border borrowing		Fulll cross-border borrowing	
	Float	Fix	Float	Fix	Float	Fix
Output	1.45	1.49	1.47	1.50	1.49	1.51
Investment	6.56	6.66	6.85	6.91	6.96	6.94
Consumption	1.81	1.79	1.80	1.78	1.81	1.79
Int.Rate	0.19	0.25	0.19	0.25	0.19	0.25
Asset Price	1.17	1.25	1.25	1.32	1.20	1.25
Inflation	0.21	0.21	0.21	0.22	0.21	0.22
Leverage E	3.25	3.31	3.49	3.53	3.59	3.60
Leverage B	6.07	6.45	4.53	7.82	5.85	6.16
Spread E	0.11	0.12	0.14	0.15	0.11	0.11

Note: Values are reported in percentage

The qualitative results are confirmed by the analysis of volatilities reported in Table 5.5. For all degrees of cross-border borrowing, the main real and financial variables are more volatile under fixed exchange rate regime, with the exception of consumption.

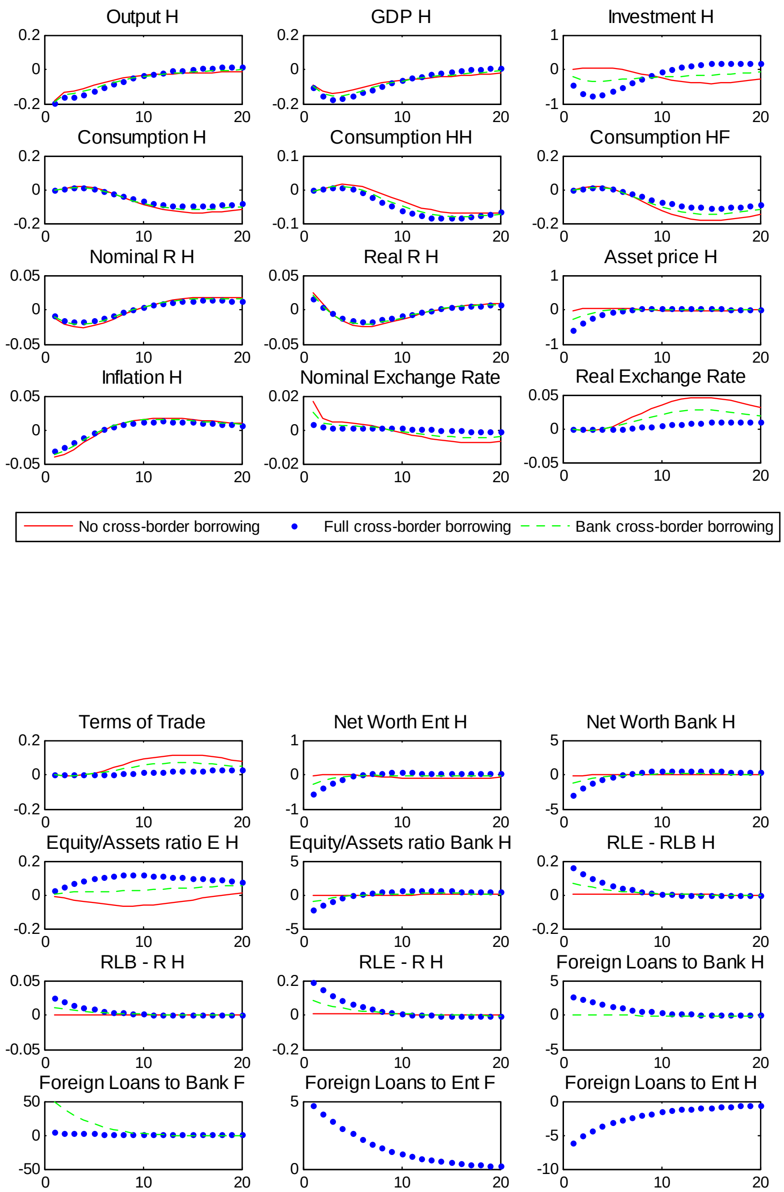
5.2.3 Foreign financial shocks

Figures (5.5), (5.6) and (5.7) and (5.8) illustrate the impulse-responses of the variables of interest to a shock to the variance of the idiosyncratic productivity of foreign banks and entrepreneurs respectively. The shock increases the volatility of the idiosyncratic productivity of banks and entrepreneurs, and can be interpreted as an increase in the riskiness of borrowers in the Foreign country. In fact, as the distribution of the stochastic idiosyncratic productivity becomes more dispersed, uncertainty about the realization of productivity increases, increasing borrowers' default probability and inducing lenders to charge a higher loan premium.

The shock to the foreign bank's idiosyncratic productivity leads to an increase in banks' borrowing spreads, which are passed on to entrepreneurs, rising their loan spreads (cfr. figure 5.11 in the Appendix). As borrowing costs rise, entrepreneurs in the foreign economy invest less, causing a decrease in the capital stock and in the price of capital. This in turn implies a decrease in foreign banks' and entrepreneurs' net worth, which reinforces the initial shock. The simultaneous decrease in output and inflation reveals that the riskiness shock has the effect of a demand shock on the foreign economy, as prices and quantities move in the same direction. The foreign central bank reacts to the fall in inflation by lowering the policy rate; however, in the first period, this is not sufficient for lowering the real interest rate, which starts decreasing only in the second period after the shock, falling below steady state values right after. The decrease in the real interest rate, by lowering the external finance premium for foreign banks, mitigates the negative financial acceleration effect triggered by the original shock. Furthermore, it increase foreign consumption, partially counteracting the initial negative effect on aggregate demand.

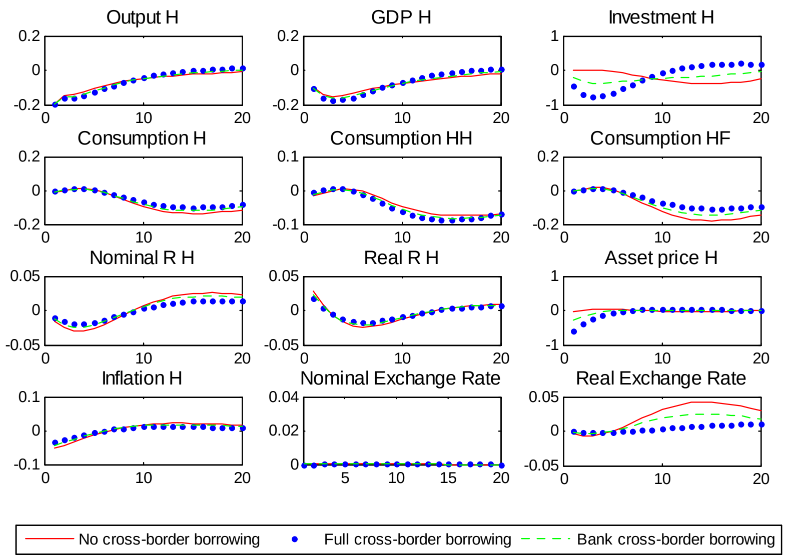
The transmission of the foreign shock differs across degrees of financial linkages. In case of domestic borrowing only, the shock is mainly transmitted through trade channels. The decrease in foreign output, investment and GDP implies a decline in Foreign demand for Home produced goods, which depresses production in the Home country. As a result, the shock is imported as a demand shock, and domestic inflation declines, leading the Home central bank to enact a monetary expansion. As the domestic nominal interest rate decreases only slightly on impact, the uncovered interest parity implies that the nominal exchange rate slightly depreciates. As a consequence of the domestic monetary policy easing, the real interest rate starts

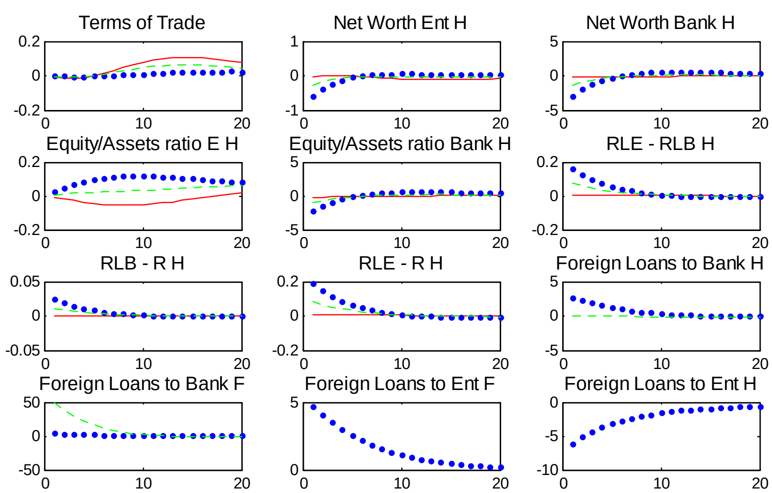
Figure 5.5: Responses of Home country to a 0.01 foreign σ_F shock: Flexible exchange rate



Note: Responses are represented in percentage deviations from the steady state

Figure 5.6: Responses of Home country to a 0.01 foreign σ_F shock: Fixed exchange rate





Note: Responses are represented in percentage deviations from the steady state

decreasing, after a brief upward jump on impact, positively impacting consumption. However, the foreign banking sector shock has virtually no effect on domestic investment and on the domestic financial sector, as lending spreads, leverage ratios and net worths are unaffected by it. Under banking and full cross-border borrowing the foreign shock spills over to the domestic economy directly through the international credit market: in particular, the tighter the financial interlinkages, the stronger the transmission of the shock. It is interesting to notice that tighter international borrowing relationships imply different dynamics in the Home and Foreign country following a banking financial shock. While stronger linkages imply a larger spillover of the shock to the Home country, they decrease its impact on the Foreign country. This results from the positive impact of the monetary policy easing in the Home country on the Foreign economy through a lowering of the cost of borrowing, while the Home country suffers the consequences of the financial shock.

In case of banks' international borrowing only, banks' and entrepreneurial lending spreads increase more markedly in the Home country, while net worth decreases more. In the case international borrowing of entrepreneurs is also allowed, the negative foreign shock is more heavily transmitted to the Home country by the credit relationship between Home entrepreneurs and Foreign banks. Here, the shock in the foreign banking sector translates in higher lending rates for domestic entrepreneurs borrowing from abroad, thereby decreasing their ability to loan funds. Hence, investment and asset prices decrease even further.

The difference in responses between fixed and flexible exchange rate regimes are only marginal, as we can see from Table 5.6. This is due to the fact that the shock, even in the case of floating currency, does not lead to sensible differences in real exchange rate fluctuations.

Table 5.6: Theoretical variances - Foreign σ_B shock

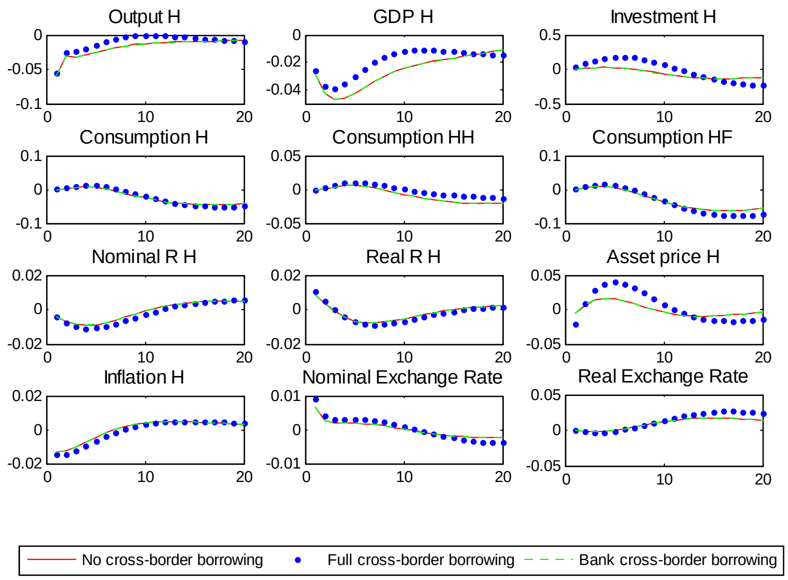
	No cross-border borrowing		Bank cross-border borrowing		Full cross-border borrowing	
	Float	Fix	Float	Fix	Float	Fix
Output	0.33	0.38	0.37	0.4	0.41	0.41
Investment	1.39	1.38	1.14	1.22	1.81	1.84
Consumption	0.49	0.49	0.43	0.43	0.35	0.36
Int.Rate	0.09	0.11	0.03	0.07	0.06	0.07
Asset Price	0.12	0.11	0.33	0.35	0.78	0.78
Inflation	0.09	0.11	0.07	0.09	0.06	0.07
Leverage E	0.25	0.25	0.42	0.44	0.64	0.65
Leverage B	0.36	0.49	1.58	1.63	3.63	3.63
Spread E	0.02	0.02	0.13	0.13	0.29	0.29

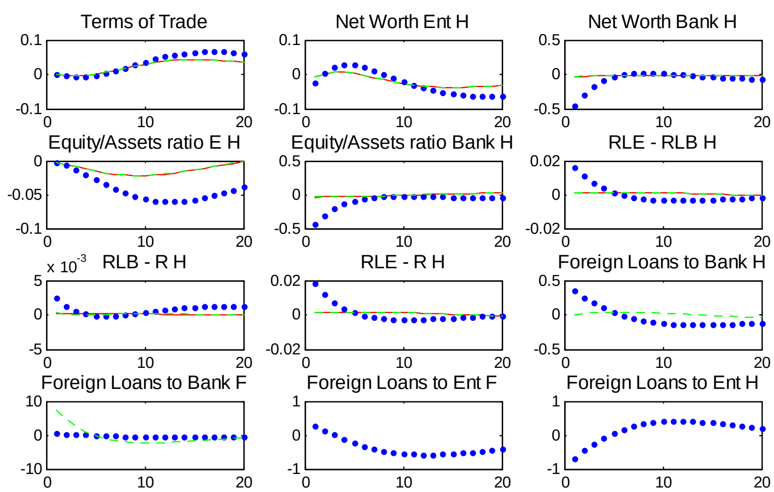
Note: Values are reported in percentageFurthermore, Table 5.6 confirms the highest volatility of the main real and financial variables in the case of full financial integration. This effect arises through two channels. First, the increase in borrowing spreads in the foreign country translates into an increase in the cost of external finance for banks and entrepreneurs in the Home country borrowing abroad, which decreases their willingness to borrow. Secondly, the decrease in foreign banks' and entrepreneurial net worth deteriorates balance sheet conditions in the Home country, and worsens borrowing conditions even further.

Figures (5.7) and (5.8) report the impulse responses relative to a foreign entrepreneurial idiosyncratic volatility shock.

Albeit in the foreign economy the shock has similar consequences as the idiosyncratic productivity shock affecting banks, its transmission to the Home country differs according to the strength of financial linkages. In the Foreign country, the shock results in an increase in the external finance premium of foreign entrepreneurs, a worsening of their borrowing conditions and a decrease in investment and asset prices. As before, the shock acts on the supply of credit, by reducing loans and increasing their price. Foreign output decreases because of the decrease in demand for investment goods and the reduction in capital stock. As before, foreign inflation falls,

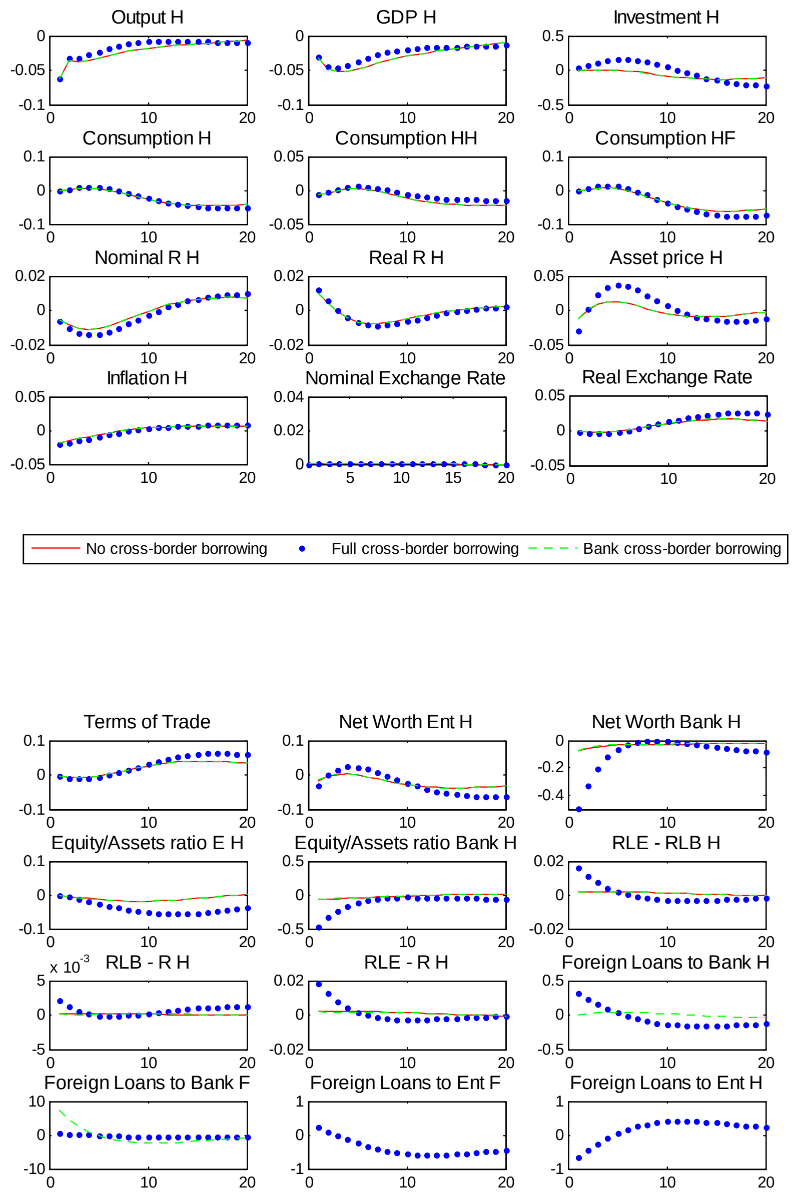
Figure 5.7: Responses of Home country to a 0.01 foreignσ_E shock: Flexible exchange rate





Note: Responses are represented in percentage deviations from the steady state

Figure 5.8: Responses of Home country to a 0.01 foreign σ_E shock: Fixed exchange rate



Note: Responses are represented in percentage deviations from the steady state

inducing the foreign central bank to ease monetary policy, which rises the real interest rate after few periods. The monetary policy action causes foreign consumption to rise and contributes to counteract the negative spiral of the financial accelerator, by easing credit conditions. Once again, the decline in Foreign demand for Home goods leads domestic output to decrease and inflation to fall, leading the Home central bank to lower its policy rate.

However, under borrowing autarky, the foreign shock has virtually no effect on domestic investment and on the domestic financial sector, as lending spreads, leverage ratios and net worths are unaffected. The case of bank cross-border borrowing is largely similar, because the domestic credit market is still insulated from the shock to entrepreneurial riskiness, as Home banks only lend to Home entrepreneurs: therefore, the shock is still transmitted through real channels. The most interesting case is that of full international borowing of banks and entrepreneurs. Now the shock to foreign entrepreneurs directly affects banks in the Home country through their international loan portfolio. As a consequence of the increase in Home banks' leverage, borrowing spreads for Home banks rise, and are passed on to entrepreneurs, even to those borrowing domestically. Then, the shock is transmitted similarly in the two countries, passing through increases in loan rates and decrease in loan demand. However, the joint effect of the monetary policy easing in the two countries acts as to counteract the negative effect of the foreign shock on the Home country. In fact, in both countries the decrease in interest rates leads to an easing of borrowing conditions. While in the Foreign country, where the shock originates and its effects are stronger, this is not sufficient to completely offset the shock, the Home country, where financial variables react less strongly than in the Foreign country, benefits from the two monetary policy actions. This is evident by looking at the behavior of entrepreneurial spreads and net worth in the Home country. After a deterioration in the first periods after the shock, spreads rapidly decrease and fall below steady state values; net worth, after an initial fall, rises above the zero line.

Also in this case, tighter international borrowing relationships imply different dynamics in the Foreign country following a entrepreneurial financial shock (cfr Figure 5.12 in the Appendix). While stronger linkages imply a larger spillover of the shock to the Home country, they decrease its impact on the financial sector in the Foreign country. This results from the positive impact of the monetary policy easing in the Home country on the Foreign economy through a lowering of the cost of borrowing.

Table 5.7: Theoretical variances - Foreign σ_E shock

	No cross-border borrowing		Bank cross-border borrowing		Full cross-border borrowing	
	Float	Fix	Float	Fix	Float	Fix
Output	0.1	0.12	0.1	0.12	0.08	0.1
Investment	0.46	0.46	0.48	0.46	0.91	0.83
Consumption	0.18	0.18	0.18	0.18	0.2	0.21
Int.Rate	0.03	0.04	0.03	0.04	0.03	0.05
Asset Price	0.04	0.04	0.04	0.04	0.03	0.05
Inflation	0.03	0.04	0.03	0.04	0.03	0.05
Leverage E	0.08	0.08	0.08	0.08	0.23	0.22
Leverage B	0.12	0.16	0.11	0.15	0.67	0.73
Spread E	0.01	0.01	0.01	0.01	0.02	0.03

Note: Values are reported in percentageComparing the impulse-responses under different exchange rate regimes (cfr Table 5.7) reveals that, although when the Home central bank pegs the currency output decreases more and investment increases less, the difference is not pronounced. Once again, this is due to the fact that the initial shock does not trigger sensible real exchange rate movements that induce expenditure switching and balance sheet effects.

5.3 Evaluation of policy regimes

In this section, I present a formal evaluation of the alternative exchange rate regimes from the perspective of the Home country. I compare the relative performance of fixed and flexible exchange rate regimes from two standpoints. First, I consider the point of view of the policymaker, i.e. the small open economy's central bank. Central banks evaluate monetary policy strategies according to their ability to meet the objectives defining their mandate. Second, I consider the ranking of alternative exchange rate regimes from the point of view of the small open economy's households, on the basis of welfare.

5.3.1 The central bank's loss function

To evaluate the performance of alternative exchange rate regimes, I first take the standpoint of the central bank in the small open economy (i.e. the Home country). Central bank's preferences are usually modeled in terms of a loss function depending on the objectives of the monetary authority. While the objectives of monetary policy traditionally involve price stability and, secondarily, sustained and stable economic activity, in recent years the issue as to whether financial stability should be explicitly included among the monetary authority's objectives has received a lot of attention[100]. In the most straightforward case in which the central bank has the traditional objectives of inflation and output stability, the loss function can be specified as follows:

$$L^{MS} = E_t\left[\hat{\pi}^2_{H,t} + \lambda_y \hat{Y}^2_{H,t} + \lambda_r \hat{R}^2_{H,t}\right] \tag{5.56}$$

Where $\hat{\pi}^2_{H,t}$, $\hat{Y}^2_{H,t}$ and $\hat{R}^2_{H,t}$ denote, respectively, squared deviations of inflation, output and the nominal interest rate from their steady state levels and the λ_j $(j = y, r)$

[100] Cfr. Section 2.6 and references therein.

are the relative weights the central bank puts on output and interest rate stability relative to inflation stability[101].

In case the monetary authority is also concerned with financial stability, the variability of financial variables is also included in the loss function, accompanied by a relative weight λ_F. I assume the central bank considers desirable to smooth the variability of leverage in the banking sector, and hence includes this variable in the set of objectives. The loss function then takes the following form:

$$L^{FS_1} = E_t \left[\hat{\pi}^2_{H,t} + \lambda_y \hat{Y}^2_{H,t} + \lambda_r \hat{R}^2_{H,t} + \lambda_F \widehat{Lev}^2_{BH,t} \right] \tag{5.57}$$

I specify two loss functions, considering different relative weights of the financial stability objective. Specifically, I set $\lambda_F = 0.1$ when the financial stability objective is of secondary importance relative to inflation stability and $\lambda_F = 1$ to represent the case in which the central bank deems inflation and financial stability equally desirable objectives.

Table 5.8: Central bank's losses (in percentage)

	No cross-border borrowing			Banks' cross-border borrowing			Full cross-border borrowing		
	Flex	Fix	Fix/Flex	Flex	Fix	Fix/Flex	Flex	Fix	Fix/Flex
Foreign R shock									
Macro	1.763	2.324	1.318	1.7685	2.324	1.3141	1.786	2.324	1.301
Macro+LevB	4.532	8.205	1.810	5.0335	8.205	1.630	5.144	8.205	1.595
Macro+LevB1	29.453	61.134	2.075	34.4185	61.134	1.776	35.366	61.134	1.728
Foreign A shock									
Macro	0.3645	0.3715	1.019	0.3665	0.3825	1.043	0.3685	0.3835	1.040
Macro+LevB	0.9715	1.0165	1.046	0.8195	1.1645	1.420	0.9535	0.9995	1.048
Macro+LevB1	6.4345	6.8215	1.060	4.8965	8.2025	1.675	6.2185	6.5435	1.052
Foreign σ_F shock									
Macro	0.1275	0.1535	1.203	0.110	0.134	1.217	0.104	0.1045	1.004
Macro+LevB	0.1635	0.2025	1.238	0.268	0.297	1.108	0.467	0.4675	1.001
Macro+LevB1	0.4875	0.6435	1.320	1.690	1.764	1.043	3.734	3.7345	1.000
Foreign σ_E shock									
Macro	0.0415	0.054	1.301	0.0415	0.054	1.301	0.0395	0.0625	1.582
Macro+LevB	0.0535	0.07	1.308	0.0525	0.069	1.314	0.1065	0.1355	1.2
Macro+LevB1	0.1615	0.214	1.325	0.1515	0.204	1.346	0.7095	0.7925	1.116

[101] In particular, I set $\lambda_y = 0.1$, $\lambda_r = 0.05$.

Table 5.8 presents the values of the loss function (in percentage) calculated using the theoretical variances implied by the model under different shocks and different degrees of cross-border borrowing. For all shocks and loss functions considered, the small open economy's central bank incurs in larger losses when pegging the exchange rate. This follows directly from the higher volatility of real and financial variables under a fixed exchange rate regime. The relationship between central bank losses and international financial linkages is more articulated. First, for a central bank concerned only with macroeconomic stability, stronger cross-border lending relationships result in a larger loss following foreign interest rate and productivity shocks. This follows from the fact that these shocks imply a monetary policy tightening in both countries as a result of inflationary pressures, which reinforce the negative impact of the shock through the financial sector, which is stronger the more tied the cross-border lending relationships between countries. On the other hand, foreign financial shocks imply a decrease in monetary policy rates in both countries, which counteract the initial impact of the shock. This effect is stronger the more countries engage in international borrowing, and smoothens the volatility of inflation in the Home country. A central bank also concerned with financial stability considers cross-border lending relationships less desirable (when evaluated only through volatilities), since they imply more variability in financial variables.

Columns 4, 7 and 10 of Table 5.8 report the relative loss experienced under a fixed exchange rate regime versus a flexible one, which can be interpreted as the relative cost of pegging for the Home economy's central bank. The relative cost of pegging decreases when shifting from a regime of domestic lending only to an environment characterized by full cross-border lending relationships between countries. When banks and entrepreneurs borrow only domestically, pegging the exchange rate results in a stronger increase in the nominal interest rate which impacts the Home country through its trading relationships with the Foreign economy and increaseses macoreconomic volatility. On the other hand, cross-border lending acts as a smoothing device, increasing the correlation of variables across countries through a sharing of the negative effect of shocks and policy actions. Therefore, the more countries entertain international borrowing relationships, the less a country's responses to a shock can act to the detriment of the other.

5.3.2 Welfare

A second metric to evaluate alternative exchange rate policies can be computed from the standpoint of Home country's households. In the presented microfounded model, the expected lifetime utility of the Home country household can be taken as a natural welfare metric. Specifically, the value function pertaining to households in the Home country conditional on the economy being in the steady state at time $t = 0$ can be expressed as:

$$V_0 = E_t \sum_{t=0}^{\infty} \beta^t U(C_t, H_t) \tag{5.58}$$

Where $U(C_t, H_t)$ is the representative household's utility function defined in equation (5.1). Then, a comparison of the two exchange rate regimes can be performed looking at the difference in the value function under fixed and under flexible exchange rates. However, as the utility function is not cardinal, a measure based on the value function is not very interesting. A more appealing measure is in terms of consumption equivalents, namely the constant fraction of consumption that households should give away under a policy regime in order to make them indifferent to a situation in which the alternative policy regime applies[102]. From equations (5.1) and (5.58), I can define the value function of households in the Home country in policy regime $j = fix, flex$ as:

[102] This approach is common in the welfare evaluation of alternative policy rule. See inter alia Devereux, Lane and Xu (2006), Ascari and Ropele (2010), Faia (2010), Kolasa and Lombardo (2011).

$$V_{j,0} = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\left(C_{j,t} - hC_{j,t-1}\right)^{1-\sigma}}{1-\sigma} - \chi_H \frac{H_{j,t}^{1+\varphi}}{1+\varphi} \right\}$$

Then, the consumption equivalent λ necessary to make households indifferent between a fixed and a flexible exchange rate regime can be calculating solving the following equation:

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\left[\left(C_{fix,t} - hC_{fix,t-1}\right)(1+\lambda)\right]^{1-\sigma}}{1-\sigma} - \chi_H \frac{H_{fix,t}^{1+\varphi}}{1+\varphi} \right\} =$$
$$= E_t \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\left(C_{flex,t} - hC_{flex,t-1}\right)^{1-\sigma}}{1-\sigma} - \chi_H \frac{H_{flex,t}^{1+\varphi}}{1+\varphi} \right\}$$

A positive value of λ implies the superiority of a flexible exchange rate regime from the perspective of Home country households. Indeed, in this case households should see their consumption increase under a peg to make them indifferent, implying that welfare under a flexible exchange rate is higher.

As in our case $\sigma = 1 \Rightarrow \frac{\left(C_{j,t} - hC_{j,t-1}\right)^{1-\sigma}}{1-\sigma} = \log\left(C_{j,t} - hC_{j,t-1}\right)$, the consumption equivalent measure is given by:

$$\lambda = 1 - \exp\left[(1-\beta)\left(V_{flex,0} - V_{fix,0}\right)\right] \tag{5.59}$$

To calculate welfare, I take a second order approximation of the model equations. Specifically, denoting as C and H the steady state values of consumption and hours worked in the Home economy, the second order approximation of utility around the steady state yields:

$$E_0\left\{U(C_t, H_t)\right\} \approx U(C,H) + U'_C(C,H) \cdot E_0\left(C_t - C\right) + U'_H(C,H) \cdot E_0\left(H_t - H\right) +$$
$$+ \frac{1}{2} U''_C(C,H) \cdot E_0\left(C_t - C\right)^2 + \frac{1}{2} U''_H(C,H) \cdot E_0\left(H_t - H\right)^2$$

This expression shows that households are concerned with both the first and second moments of consumption and hours worked. Specifically, household utility increases with the conditional mean of consumption, decreases the higher the conditional mean of hours worked and decreases the higher the conditional variance of both consumption and labor supply.

Table 5.9: Relative welfare ranking of fixed and flexible exchange rate regimes

	No cross-border borrowing	Banks' cross border borrowing	Full cross-border borrowing
Foreign R shock	0.3052	0.3195	0.3100
Foreign A shock	0.0028	0.0029	0.0029
Foreign σ_F shock	0.0007	0.0006	0.0004
Foreign σ_E shock	-0.0001	-0.0001	-0.0002

Table 5.9 presents the consumption equivalents for each shock and different degrees of cross-border borrowing. For all shock considered except the shock to foreign entrepreneurs' productivity, a flexible exchange rate is preferable from a welfare perspective. The difference between exchange rate regimes is particularly pronounced for foreign interest rate shocks. In fact, under a fixed exchange rate, households should be offered more than 30% of consumption to bring their welfare equal to the flexible exchange rate regime case. However, for foreign productivity and financial shocks the welfare difference across exchange rate regimes is smaller, and becomes almost negligible for foreign financial shocks. Concerning different degrees of financial linkages, the welfare difference between exchange rate regimes is slightly lower when there is no international borrowing and lending.

5.4 Sensitivity analysis

In what follows, I report synthetic results obtained by perturbing the model on several grounds, in order to test the robustness of the results reported in the previous sections to alternative model specifications and parametrization.

First, I test the sensitivity of my results to a specification of the model where credit contracts are stipulated in nominal terms.

As noted by Dib, Mendicino and Zhang (2008), nominal assets introduce private risk given by uncertain returns. In fact, the external finance premium in non-indexed contracts is directly linked to expected inflation and, if foreign borrowing is allowed, to expected movements in the nominal exchange rate. Credit contracts stipulated in nominal terms, therefore, introuduce a Fisher "debt deflation" effect[103]: unexpected changes in the price level alter the real value of debt. Furthermore, loan repayments depend on the ex-post real value of debt. An unanticipated increase (decrease) in inflation reduces (increases) the the real cost of debt repayments, boosting (reducing) borrowers' net worth. Hence, nominal contracts introduce a redistribution of wealth between borrowers and lenders due to unexpected fluctuations in debt services. Moreover, with nominal contracts, disinflation reinforces the financial accelerator mechanism, thereby dampening the expansionary effects of a decrease in prices. Therefore, from a monetary policy point of view, nominal contracts give a central bank an incentive not to respond aggressively to a shock with inflationary pressures.

Figures (5.13) to (5.16) in the Appendix report the results of model simulations with nominal debt contracts. As a consequence of a foreign interest rate shock, the negative effect on the small open economy's output is slightly more pronounced than in the baseline case. This a-priori counterintuitive result can be explained by the dynamic of inflation in the two countries. In the Home country, the foreign shock results in an increase in inflation. This counteracts the negative spiral induced by the financial accelerator effect by making the real cost of debt cheaper and the real debt burden lower. However, the opposite occurs in the Foreign country, where inflation

[103] See Christensen and Dib (2008) and Christiano, Motto and Rostagno (2010) for details on the Fisher debt deflation effect in DSGE models with financial frictions.

decreases after the shock, thereby reinforceing the negative acceleration effect and decreasing Foreign output even more. This gets transmitted to the Home country through trade channels, but also through cross-border exposures. Indeed, in case of international borrowing, borrowers in the home country are negatively affected by the decrease in foreign inflation.

The opposite result can be observed in case of a foreign productivity shock. In this case, inflation increases in both countries and mitigates the adverse effect of the shock. This results in a less strong effect of the disturbance on output in both countries relative to the baseline scenario. Finally, differences between the nominal contract and the baseline scenario are negligible in the case of financial shocks. This is mainly due to the small effect these shocks exert on inflation.

As a second robustness exercise, I change the relative size of the small country and its trade openness. In the baseline specification presented in the main text, I set $n \to 0$ and $\lambda = 0.4$ (the trade openness parameter). This implied that the shares of domestic and imported goods in the Home country's consumption basket were respectively equal to $\gamma = 0.6$ and $(1 - \gamma) = 0.4$. This implied that economic developments in the Home country had no repercussions on the Foreign country, but not vice-versa.

As a first check, I change the parameters n and λ to imply a different relative country size and trade openness, but the same values of the parameter γ. Specifically, I set $n = 0.5$ (implying equal country size) and $\lambda = 0.8$. In the second case, I set $n \to 0$ and $\lambda = 0.1$, so that $\gamma = 0.9$ and $(1 - \gamma) = 0.1$, and the Home country consumes only a very small share of Foreign goods.

This allows for stronger feedback effects between countries, which operate mainly through trade channels. Allowing for greater inter-country feedbacks implies that the Foreign country is going to be influenced by changes in international relative prices, because now the share of imports from the Home country is not negligible in the Foreign consumption basket, and this is going to have repercussions on the small country. Therefore, the real exchange rate, which can be shown to be dependent on the openness parameters of the two countries, in turn related to the relative country size in this model, is going to be influenced by domestic developments. The impulse responses represented in Figures (5.17) and (5.18) in the Appendix[104] show that these alternative calibrations show that the real exchange rate in this version of the model is less volatile than in the baseline. However, this does not alter the conclusions regarding the better performance of flexible exchange rates in isolating the economy from external shocks, nor the interaction between exchange rate regimes and degrees of financial integration

As a third robustness check, change the parametrization of the financial accelerator mechanism, since my calibration based on European data yields different values for the parameters representing monitoring costs and idiosyncratic volatilities in the banking and entrepreneurial sectors than in the paper by Ueda (2012), as shown in Table 5.10:

[104] For space reasons I show only the responses to the main model variables to a foreign productivity shock under a fixed and flexible exchange rate regime.

Table 5.10: Alternative Calibration Financial Accelerator

	Baseline calibration	Ueda (2012) calibration
[0.5ex] $\mu_{E,H}$	0.033	0.013
$\mu_{E,F}$	0.033	0.013
$\mu_{F,H}$	0.243	0.033
$\mu_{F,F}$	0.243	0.033
γ_E	0.985	0.984
γ_F	0.969	0.963
QK/NW_e	0.490	0.5
QK/NW_f	0.104	0.1
R^k/R	1.0049	1.005
$Z^E - Z^F$	0.0052	$0.023^0.25$
$Z^F - R$	0.0004	$0.006^0.25$
$F(\bar{\omega_E})$	0.0075	0.02
$F(\bar{\omega_F})$	0.0015	0.02

As the alternative calibration does not alter the results, I omit the impulse-response functions for space reasons.

5.5 Conclusion

This paper examines the interaction between financial interlinkages and exchange rate regimes in a small open economy, obtained as the limit of a two-country DSGE model with real and financial frictions. In particular, it compares the performance of fixed versus flexible exchange rate regimes in stabilizing a small open economy facing foreign nominal, real and financial shocks under different degrees of cross-border borrowing.

The superiority of a flexible exchange rate regime in stabilizing an economy facing foreign shocks (affirmed, inter alia, by Faia (2010)) is confirmed. Specifically, following a foreign interest rate and technology shock, economic activity in the Home country suffers more when the currency is pegged. The difference across exchange rate regimes is more muted in case of foreign financial shocks. This results from the very weak impact of these shocks on economic activity, inflation and the real exchange rate in the Home country.

A floating exchange rate regimes ranks higher from the perspective of both the central bank and household welfare in the Home economy. From the point of view of the Home country's monetary authority, the relative cost of pegging the currency increases the larger the weight it places in the financial stability's objective. This results from the stronger monetary policy response necessary to preserve the parity, which has repercussions for the volatility of financial variables. From a welfare standpoint, pegging the exchange rate is least desirable when the economy is hit by foreign interest rate shocks. In this case, the foreign shock is entirely "imported", implying a rise in the domestic policy rate of the same magnitude of the adverse foreign shock. The large swing in the policy rate leads to a revision of consumers' intertemporal consumption allocations, causing a decrease in average consumption and an increaase of its volatility.

The interaction between exchange rate policies and degrees of cross-border borrowing is less straightforward. Simulation results suggest that, first of all, the greatest difference in responses across degrees of international borrowing is observed following shocks that directly impact the financial sector (i.e. foreign interest rate and financial shocks). The transmission of a foreign technology shock is not markedly different the more the two countries engage in cross-border borrowing relationships. This results because, unlike the other shocks considered, the technology shock is transmitted mainly through "real" channels and it affects financial variables only through changes in demand for capital investment and asset prices.

Secondly, when the Home country pegs the currency, the dynamic adjustment of the Home economy after foreign interest rate and productivity shocks does not differ across degrees of cross-border borrowing. This is largely driven by the assumed structure of international credit contracts. A foreign interest rate shock under pegged exchange rate cause a specular increase of the nominal interest rate in the Home country. Given the symmetric structure of cross-border exposures, the shock has the same effect no matter whether banks or entrepreneurs borrow from the Foreign country. In case of a foreing productivity shock, this applies even when the Home country's monetary authority allows the currency to float. In this case, however, the result is driven by the opposite effect real exchange rate movements exert on the asset and liability side of banks' balance sheets, which offset each other.

From the Home country central bank's viewpoint, stronger cross-border lending relationships result in larger losses when macroeconomic stability is the only objective and the economy is hit by foreign interest rate and productivity shocks. This relationship is inversed when the economy is subject to foreign financial shocks.

Finally, I find that the relative cost of pegging the currency from the Home monetary authority's standpoint decreases the stronger the degree of cross-border borrowing. International credit contracts act as a "smoothing" device, increasing the correlation between countries and allowing them to share the burden of adverse shocks and policy actions.

The present study constitutes a first attempt to study the interaction between financial integration and exchange rate policy in a New Keynesian model with cross-border lending. While the presented exercise leads to interesting insights, it opens the way for further analysis. First of all, in its current formulation, the model specifies symmetric cross-border financial exposures. This implies that, taking as examples of the two countries Hungary and the Euro Area, in the current specification, the Euro Area borrows from Hungary as much as the latter borrows from the Euro Area. This hypothesis is clearly not representative of reality. However, its abandonment requires a reformulation of the modeling of financial intermediaries and cross-border credit contracts, and will be undertaken in future work. Secondly, in this study I neglected issues related to the interaction between trade and financial openness. The presented analysis was performed varying the degree of financial integration, but leaving the trade openness parameter unchanged. Furthermore, it was conducted under the assumption of perfect exchange rate pass-through. Examining the interaction between trade and financial openness, the degree of exchange rate pass-through for international transmission of shocks is surely an interesting avenue of future research. Thirdly, this framework could be adapted to analyze issues related to small countries with large, internationally operating financial sectors, as it is the case of Cyprus. Finally, testing the ability of the model to account for the transmission of the financial crisis through Bayesian estimation would lead to interesting insights on the appropriateness of the chosen modeling strategy in accounting for actual economic dynamics. This exercise is currently in progress.

5.A Appendix

5.A.1 Model equations

In what follows, the complete set of stationary equilibrium relationships are presented. In equilibrium, only relative prices are define. In every country, nominal prices are deflated by the composite price index, resulting in the following definitions:

$$\begin{aligned} p_{HH,t} &= \frac{P_{H,t}}{P_t}; \quad p_{HF,t} = \frac{P_{F,t}}{P_t}; \\ p_{FH,t} &= \frac{P^*_{H,t}}{P^*_t}; \quad p_{FF,t} = \frac{P^*_{F,t}}{P^*_t}; \end{aligned}$$

Hence, the following relationships linking relative prices and inflation are derived:

$$\begin{aligned}
\pi_{HH,t} &= \frac{p_{HH,t}}{p_{HH,t-1}}\pi_{H,t} \\
\pi_{HF,t} &= \frac{p_{HF,t}}{p_{HF,t-1}}\pi_{H,t} \\
\pi_{FF,t} &= \frac{p_{FF,t}}{p_{FF,t-1}}\pi_{F,t} \\
\pi_{FH,t} &= \frac{p_{FH,t}}{p_{FH,t-1}}\pi_{F,t}
\end{aligned}$$

Furthermore, the equations of the price levels are rewritten as:

$$\begin{aligned}
1 &= p_{HH,t}^{\gamma} p_{HF,t}^{(1-\gamma)} \\
1 &= p_{FF,t}^{(1-\gamma^*)} p_{FH,t}^{\gamma^*}
\end{aligned}$$

In addition, the relationships between relative prices, the real exchange rate and the terms of trade can be formulated as:

$$\begin{aligned}
p_{FH,t} &= \frac{1}{\varepsilon_t} p_{HH,t} \\
p_{HF,t} &= \varepsilon_t p_{FF,t} \\
\varepsilon_t &= \frac{S_t}{S_{t-1}} \frac{\pi_{F,t}}{\pi_{H,t}} \\
TOT_t &= \varepsilon_t \frac{p_{HF,t}}{p_{HH,t}}
\end{aligned}$$

The complete equilibrium conditions for the Home country are presented. An analogous set of equations holds for the Foreign economy.

$$\begin{aligned}
\mu_t &= (C_t - hC_{t-1})^{-\sigma} \\
\mu_t &= \beta E_t \left\{ \mu_{t+1} \frac{R_t}{\pi_{t+1}} \right\} \\
w_t &= \frac{\varepsilon_w}{\varepsilon_w - 1} \frac{\chi_H H_t^{\varphi}}{\mu_t}
\end{aligned}$$

$$C_{H,t} = \gamma \left(\frac{P_{H,t}(j_H)}{P_{H,t}} \right)^{-\varepsilon} \left(\frac{P_{H,t}}{P_t} \right)^{-1} C_t$$
$$C_{F,t} = (1-\gamma) \left(\frac{P_{F,t}(j_F)}{P_{F,t}} \right)^{-\varepsilon} \left(\frac{P_{F,t}}{P_t} \right)^{-1} C_t$$

$$\begin{aligned}
K_t^w &= \left(\frac{\varepsilon_w - 1}{\varepsilon_w} \right) \tilde{W}_t \mu_t H_t \left(\frac{W_t}{\tilde{W}_t} \right)^{\varepsilon_w} + \beta \theta^w \left(\frac{\pi_{H,t+1}}{\pi_{H,t}} \frac{\tilde{W}_{t+1}}{\tilde{W}_t} \right)^{\varepsilon_w - 1} K_{t+1}^w \\
F_t^w &= \chi_H \left(H_t^d \right)^{\varphi} \left(\frac{W_t}{\tilde{W}_t} \right)^{\varepsilon_w} H_t + \beta \theta^w \left(\frac{\pi_{H,t+1}}{\pi_{H,t}} \frac{\tilde{W}_{t+1}}{\tilde{W}_t} \right)^{\varepsilon_w} F_{t+1}^w \\
K_t^w &= F_t^w
\end{aligned}$$

$$W_t = \left[(1-\theta^w) \tilde{W}_t^{1-\varepsilon_w} + \theta^w \left(W_{t-1}(i) \pi_{t-1} \right)^{1-\varepsilon_w} \right]^{\frac{1}{1-\varepsilon_w}}$$

$$\varepsilon_t = \frac{\mu_t^{*-\sigma}}{\mu_t^{-\sigma}}$$

$$Y_{H,t} = A_t K_{H,t}^{\alpha} H_t^{1-\alpha}$$

$$W_t = MC_t (1-\alpha) \frac{Y_t}{H_t}$$

$$r_t^K = MC_t \alpha \frac{Y_t}{K_t}$$

$$P_{H,t} = \left[\theta_H \left(P_{H,t-1} \pi_{t-1}^{\gamma_p} (\pi^{ss})^{1-\gamma_p} \right)^{1-\varepsilon_H} + (1-\theta_H) \tilde{P}_{H,t}^{1-\varepsilon_H} \right]^{\frac{1}{1-\varepsilon_H}}$$

$$\begin{aligned}\frac{\tilde{P}_{H,t}}{P_{H,t}} &= \frac{\varepsilon_H}{\varepsilon_H - 1}\frac{F_{H,t}}{D_{H,t}} \\ F_{H,t} &= \frac{\Lambda_t}{P_t} P_{H,t} mc_{H,t} Y_t^H + \beta\theta_H E_t \left\{ \left(\pi_{t+1}^H\right)^{\varepsilon_H} F_{H,t+1} \right\} \\ D_{H,t} &= \frac{\Lambda_t}{P_t} P_{H,t} Y_t^H + \beta\theta_H E_t \left\{ \left(\pi_{t+1}^H\right)^{\varepsilon_H - 1} D_{H,t+1} \right\}\end{aligned}$$

$$\begin{aligned}1 \quad = \quad & q_{H,t}\left[1 - \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \kappa\left(\frac{I_t}{I_{t-1}} - 1\right)\left(\frac{I_t}{I_{t-1}}\right)\right] + \\ & + \beta E_t\left\{\frac{\Lambda_{t+1}}{\Lambda_t} q_{H,t+1}\left[\kappa\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]\right\}\end{aligned}$$

$$K_{t+1} = \left[1 - \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t + (1-\delta) K_t$$

$$\begin{aligned}I_{H,t} &= \gamma\left(\frac{P_{H,t}(j_H)}{P_{H,t}}\right)^{-\varepsilon}\left(\frac{P_{H,t}}{P_t}\right)^{-1} I_t \\ I_{F,t} &= (1-\gamma)\left(\frac{P_{F,t}(j_F)}{P_{F,t}}\right)^{-\varepsilon}\left(\frac{P_{F,t}}{P_t}\right)^{-1} I_t\end{aligned}$$

$$\begin{aligned}R_{HH,t}^E &= \frac{r_t^K + (1-\delta) Q_{H,t}}{Q_{H,t-1}} \\ R_{HF,t}^E &= \frac{r_t^K + (1-\delta) Q_{H,t}}{Q_{H,t-1}}\end{aligned}$$

$$\begin{aligned}\bar{\omega}_{HH,t+1}^E R_{HH,t+1}^E Q_{H,t} K_{HH,t} &= Z_{HH,t+1}^E \left(Q_{H,t} K_{HH,t} - NW_{H,t}^E\right) \\ \bar{\omega}_{FH,t+1}^E R_{FH,t+1}^E Q_{F,t} K_{FH,t} &= Z_{FH,t+1}^E \left(Q_{F,t} K_{FH,t} - NW_{F,t}^E\right)\end{aligned}$$

$$\bar{\omega}^F_{HH,t+1} R^F_{t+1} \left[\left(1-\tau^E_H\right) \left(Q_{H,t} K_{HH,t} - NW^E_{H,t}\right) + \tau^E_F \varepsilon_t \left(Q_{F,t} K_{FH,t} - NW^E_{F,t}\right) \right] = Z^F_{HH,t+1} L^F_t$$
$$\bar{\omega}^F_{HF,t+1} R^F_{t+1} \left[\left(1-\tau^E_H\right) \left(Q_{H,t} K_{HH,t} - NW^E_{H,t}\right) + \tau^E_F \varepsilon_t \left(Q_{F,t} K_{FH,t} - NW^E_{F,t}\right) \right] = Z^F_{HF,t+1} L^F_t$$

$$\begin{aligned} 0 = &\left\{ \begin{array}{c} R^E_{HH,t+1} \left[\left(1-\Gamma^E_{HH}\left(\omega^E_{HH,t+1}\right)\right) \Phi^{E\prime}\left(\omega^E_{HH,t+1}\right) + \Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right) \Phi^E\left(\omega^E_{HH,t+1}\right) \right] \cdot \\ \left[\left(1-\Gamma^F\left(\omega^F_{HH,t+1}\right)\right)\left(1-\tau^F_H\right) + \left(1-\Gamma^F\left(\omega^F_{HF,t+1}\right)\right)\tau^F_H \right] \end{array} \right\} + \\ &+ (1-\tau^F_H) \frac{\Gamma^{F\prime}\left(\omega^F_{HH,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HH,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right) \Phi^F\left(\omega^F_{HH,t+1}\right) R^E_{HH,t+1} \Phi^E\left(\omega^E_{HH,t+1}\right) \\ -R_t \Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right) + \\ \Phi^F\left(\omega^F_{HH,t+1}\right) \Phi^{E\prime}\left(\omega^E_{HH,t+1}\right) \left(1-\Gamma^E_H\left(\omega^E_{HH,t+1}\right)\right) R^E_{HH,t+1} \end{array} \right] + \\ &+ \tau^F_H \frac{\Gamma^{F\prime}\left(\omega^F_{HF,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HF,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right) \Phi^F\left(\omega^F_{HF,t+1}\right) R^E_{HH,t+1} \Phi^E\left(\omega^E_{HH,t+1}\right) \\ -R^*_t \frac{\varepsilon_{t+1}}{\varepsilon_t} \Gamma^{E\prime}_H\left(\omega^E_{HH,t+1}\right) + \\ \Phi^F\left(\omega^F_{HF,t+1}\right) \Phi^{E\prime}\left(\omega^E_{HH,t+1}\right) \left(1-\Gamma^E_H\left(\omega^E_{HH,t+1}\right)\right) R^E_{HH,t+1} \end{array} \right] \end{aligned}$$

$$\begin{aligned} 0 = &\left\{ \begin{array}{c} R^E_{FH,t+1} \left[\left(1-\Gamma^E_H\left(\omega^E_{FH,t+1}\right)\right) \Phi^{E\prime}\left(\omega^E_{FH,t+1}\right) + \Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right) \Phi^E\left(\omega^E_{FH,t+1}\right) \right] \cdot \\ \left[\left(1-\Gamma^F\left(\omega^F_{HH,t+1}\right)\right)\left(1-\tau^F_H\right) + \left(1-\Gamma^F\left(\omega^F_{HF,t+1}\right)\right)\tau^F_H \right] \end{array} \right\} + \\ &+ (1-\tau^F_H) \frac{\Gamma^{F\prime}\left(\omega^F_{HH,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HH,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right) \Phi^F\left(\omega^F_{HH,t+1}\right) R^E_{FH,t+1} \Phi^E\left(\omega^E_{FH,t+1}\right) \\ -R_t \Gamma^{E\prime}_{FH}\left(\omega^E_{FH,t+1}\right) \\ +\Phi^F\left(\omega^F_{HH,t+1}\right) \Phi^{E\prime}\left(\omega^E_{FH,t+1}\right) \left(1-\Gamma^E_{FH}\left(\omega^E_{FH,t+1}\right)\right) R^E_{FH,t+1} \end{array} \right] + \\ &+ \tau^F_H \frac{\Gamma^{F\prime}\left(\omega^F_{HF,t+1}\right)}{\Phi^{F\prime}\left(\omega^F_{HF,t+1}\right)} \left[\begin{array}{c} \Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right) \Phi^F\left(\omega^F_{HF,t+1}\right) R^E_{FH,t+1} \Phi^E\left(\omega^E_{FH,t+1}\right) - \\ R^*_t \frac{\varepsilon_{t+1}}{\varepsilon_t} \Gamma^{E\prime}_H\left(\omega^E_{FH,t+1}\right) \\ +\Phi^F\left(\omega^F_{HF,t+1}\right) \Phi^{E\prime}\left(\omega^E_{FH,t+1}\right) \left(1-\Gamma^E_H\left(\omega^E_{FH,t+1}\right)\right) R^E_{FH,t+1} \end{array} \right] \end{aligned}$$

$$(1-\tau_H^F)\Phi^F\left(\omega_{HH,t+1}^F\right)\cdot\left[\begin{array}{c}\left(1-\tau_H^E\right)R_{HH,t+1}^E Q_{H,t}K_{HH,t}\Phi^E\left(\omega_{HH,t+1}^E\right)+\\ \tau_F^E R_{FH,t+1}^E\frac{\varepsilon_{t+1}}{\varepsilon_t}Q_{F,t}K_{FH,t}\Phi^E\left(\omega_{FH,t+1}^E\right)\end{array}\right]=$$
$$R_t(1-\tau_H^F)\left[\left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right)-NW_{H,t}^F\right]$$
$$\tau_H^F\Phi^F\left(\omega_{HF,t+1}^F\right)\cdot\left[\begin{array}{c}\left(1-\tau_H^E\right)R_{HH,t+1}^E Q_{H,t}K_{HH,t}\Phi^E\left(\omega_{HH,t+1}^E\right)+\\ \tau_F^E R_{FH,t+1}^E\frac{\varepsilon_{t+1}}{\varepsilon_t}Q_{F,t}^*K_{FH,t}\Phi^E\left(\omega_{FH,t+1}^E\right)\end{array}\right]=$$
$$R_t^*\frac{\varepsilon_{t+1}}{\varepsilon_t}\tau_H^F\left[\left(1-\tau_H^E\right)\left(Q_{H,t}K_{HH,t}-NW_{H,t}^E\right)+\tau_F^E\varepsilon_t\left(Q_{F,t}K_{FH,t}-NW_{F,t}^E\right)-NW_{H,t}^F\right]$$
$$\left[1-\Gamma_{HH}^E\left(\omega_{HH,t+1}^E\right)\right]R_{HH,t+1}^E Q_{H,t}K_{HH,t}=R_{HH,t+1}^E NW_{H,t}^E$$
$$\left[1-\Gamma_{FH}^E\left(\omega_{FH,t+1}^E\right)\right]R_{FH,t+1}^E Q_{F,t}K_{FH,t}=R_{FH,t+1}^E NW_{F,t}^E$$

$$NW_{H,t}^E=\gamma^E V_{H,t}^E+W_{H,t}^E$$
$$NW_{H,tt}^F=\gamma^F V_{H,t}^F+W_{H,t}^F$$

$$\begin{aligned}V_{H,t}^E&=\left[1-\Gamma_{HH,t-1}^E\left(\bar{\omega}_{HH,t}^E\right)\right]\left(1-\tau_H^E\right)R_{HH,t}^E Q_{H,t-1}K_{HH,t-1}+\\&\quad+\left[1-\Gamma_{HF,t-1}^E\left(\bar{\omega}_{HF,t}^E\right)\right]\tau_H^E R_{HF,t}^E Q_{H,t-1}K_{HF,t-1}\\ V_{H,t}^F&=\left[1-\Gamma_{HH,t-1}^F\left(\bar{\omega}_{HH,t}^F\right)\right]\left(1-\tau_H^F\right)R_{H,t}^F\left\{\begin{array}{c}\left(1-\tau_H^E\right)\left(Q_{H,t-1}K_{HH,t-1}-NW_{H,t-1}^E\right)\\ +\tau_F^E\varepsilon_{t-1}\left(Q_{F,t-1}K_{FH,t-1}-NW_{F,t-1}^E\right)\end{array}\right\}+\\&\quad+\left[1-\Gamma_{HF,t-1}^F\left(\bar{\omega}_{HF,t}^F\right)\right]\tau_H^F R_{H,t}^F\left\{\begin{array}{c}\left(1-\tau_H^E\right)\left(Q_{H,t-1}K_{HH,t-1}-NW_{H,t-1}^E\right)\\ +\tau_F^E\varepsilon_{t-1}\left(Q_{F,t-1}K_{FH,t-1}-NW_{F,t-1}^E\right)\end{array}\right\}\end{aligned}$$

$$C_{H,t}^E=\left(1-\gamma^E\right)V_{H,t}^E$$
$$C_{H,t}^F=\left(1-\gamma^F\right)V_{H,t}^F$$

$$C^E_{H,t} = \gamma \left(\frac{P_{H,t}(j_H)}{P_{H,t}} \right)^{-\varepsilon} \left(\frac{P_{H,t}}{P_t} \right)^{-1} C^E_t$$
$$C^E_{F,t} = (1-\gamma) \left(\frac{P_{F,t}(j_F)}{P_{F,t}} \right)^{-\varepsilon} \left(\frac{P_{F,t}}{P_t} \right)^{-1} C^E_t$$

$$C^F_{H,t} = \gamma \left(\frac{P_{H,t}(j_H)}{P_{H,t}} \right)^{-\varepsilon} \left(\frac{P_{H,t}}{P_t} \right)^{-1} C^F_t$$
$$C^F_{F,t} = (1-\gamma) \left(\frac{P_{F,t}(j_F)}{P_{F,t}} \right)^{-\varepsilon} \left(\frac{P_{F,t}}{P_t} \right)^{-1} C^F_t$$

$$K_t = \left(1-\tau^E_H\right) K_{HH,t} + \tau^E_H K_{HF,t}$$

$$Y_{H,t} = \Delta_{H,t} \left(C_{H,t} + C^E_{H,t} + C^F_{H,t} + I_{H,t} + G_t + M_t\right) + \Delta^*_{H,t} \frac{(1-n)}{n} \left(C^*_{H,t} + C^{E*}_{H,t} + C^{F*}_{H,t} + I^*_{H,t}\right)$$

$$\begin{aligned}
M_t = {} & \mu^E G^E \left(\bar{\omega}^E_{HH,t}\right) R^E_{HH,t} \left(1-\tau^E_H\right) Q_{H,t-1} K_{HH,t-1} + \\
& + \mu^E G^E \left(\bar{\omega}^E_{FH,t}\right) R^E_{FH,t} \varepsilon_{t-1} \tau^E_F Q_{F,t-1} K_{FH,t-1} + \\
& + \mu^F G^F \left(\bar{\omega}^F_{HH,t}\right) R^F_{Ht} \left(1-\tau^F_H\right) \left[\begin{array}{c} \left(1-\tau^E_H\right)\left(Q_{H,t-1}K_{HH,t-1} - NW^E_{H,t-1}\right) \\ +\tau^E_F \varepsilon_{t-1} \left(Q_{F,t-1}K_{FH,t-1} - NW^E_{F,t-1}\right) \end{array} \right] + \\
& + \mu^F G^F \left(\bar{\omega}^F_{FH,t}\right) \tau^F_F \varepsilon_{t-1} R^F_{FH,t} \left[\begin{array}{c} \frac{1}{\varepsilon_{t-1}} \tau^E_H \left(Q_{H,t-1}K_{HF,t-1} - NW^E_{H,t-1}\right) \\ +(1-\tau^E_F)\left(Q^*_{F,t-1}K^*_{FF,t-1} - NW^E_{F,t-1}\right) \end{array} \right]
\end{aligned}$$

$$\begin{aligned}
\Delta_{H,t} &= (1-\theta_H) \left[\frac{1-\theta_H \left(\frac{1}{\pi_{H,t}}\right)^{1-\varepsilon_H}}{1-\theta_H} \right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}} + \theta_H \left(\frac{1}{\pi_{H,t}} \right)^{-\varepsilon_H} \Delta_{H,t-1} \\
\Delta^*_{H,t} &= (1-\theta_H) \left[\frac{1-\theta_H \left(\frac{1}{\pi^*_{H,t}}\right)^{1-\varepsilon_H}}{1-\theta_H} \right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}} + \theta_H \left(\frac{1}{\pi^*_{H,t}} \right)^{-\varepsilon_H} \Delta^*_{H,t-1}
\end{aligned}$$

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_r} \left[\left(\frac{\pi_{H,t}}{\pi_H}\right)^{\rho_\pi} \left(\frac{S_t}{S}\right)^{\frac{1}{1-\rho_S}}\right]^{(1-\rho_r)} \exp(\xi_{R,t})$$

5.A.2 Expressions related to optimal credit contract

As in BGG(1999), the idiosyncratic shocks of domestic and foreign entrepreneurs and financial intermediaries ($\omega^E_{HH,t}, \omega^E_{HF,t}, \omega^E_{FH,t}, \omega^E_{FF,t}, \omega^F_{HH,t}, \omega^F_{HF,t}, \omega^F_{FH,t}, \omega^F_{FF,t}$) are log-normally distributed with $E(\omega_{ij,t} = 1)$. I denote $f(\omega_{ij})$ the probability distribution function and $F(\omega_{ij})$ the cumulative distribution function of ω_{ij}. Hence:

$$f(\bar{\omega}_{ij}; -\frac{\sigma^2}{2}, \sigma) = \frac{1}{\bar{\omega}_{ij}\sigma\sqrt{2\pi}} e^{-\frac{\left(\log\bar{\omega}_{ij}+\frac{\sigma^2}{2}\right)^2}{2\sigma^2}} = \frac{1}{\bar{\omega}_{ij}\sigma} Npdf\left(\frac{\log\bar{\omega}_{ij} + 0.5\sigma^2}{\sigma}\right)$$

$$F(\bar{\omega}_{ij}; -\frac{\sigma^2}{2}, \sigma) = \int_0^{\bar{\omega}_{ij}} f(\omega_{ij}) d\omega_{ij} = \frac{1}{\sqrt{2\pi}} \int_0^{\frac{\log\omega_{ij}+\frac{\sigma^2}{2}}{\sigma}} e^{-t^2} dt = Ncdf\left(\frac{\log\bar{\omega}_{ij} + 0.5\sigma^2}{\sigma}\right)$$

$$\begin{aligned}
G(\omega_{ij};\sigma) &= \int_0^{\bar{\omega}_{ij}} \omega_{ij} f(\omega_{ij}) d\omega_{ij} = Ncdf\left(\frac{\log\bar{\omega}_{ij} - 0.5\sigma^2}{\sigma}\right) \\
\Gamma(\omega_{ij};\sigma) &= \bar{\omega}_{ij}\left[1 - F(\bar{\omega}_{ij})\right] + G(\omega_{ij};\sigma) \\
\Gamma'(\omega_{ij};\sigma) &= \left[1 - F(\bar{\omega}_{ij})\right] \\
G'(\omega_{ij};\sigma) &= \bar{\omega}_{ij} f(\bar{\omega}_{ij}) \\
\Phi(\omega_{ij};\sigma) &= \Gamma(\omega_{ij};\sigma) - \mu_{ij} G(\omega_{ij};\sigma) \\
\Phi'(\omega_{ij};\sigma) &= \Gamma'(\omega_{ij};\sigma) - \mu_{ij} G'(\omega_{ij};\sigma)
\end{aligned}$$

5.A.3 Steady state

As the model is not solvable in closed form, I perform the analysis by linearizing the model equations around the non-stochastic steady state with zero inflation and no exchange rate depreciation. In the deterministic steady state, all shocks are equal to their mean values, and all (gross) inflation rates are equal to 1. Furthermore, marginal costs and markups are the same for all firms in the economy, hence all relative prices are equal to 1 and price dispersion is equal to 1. Finally, in the steady state consumption is equalized across countries and the net foreign asset position is zero.

Assume $A_{NT} = A_H = A^*_{NT} = A_F = 1$.

$$\pi_t = \pi^*_t = \pi^H_t = \pi^{NT}_t = \pi^F_t = \pi^{NT*}_t = 1$$

Normalize nominal exchange rate:

$$S_t = 1$$

Use Consumption Euler:

$$R_t = \frac{1}{\beta} = R^*_t$$

From the Tobin's Q equation I obtain:

$$Q_t = Q^*_t = 1$$

5.A.4 Credit markets and financial frictions

The steady state of the credit market is computed assuming target values for six quantities: (1) The risk premium for entrepreneurs $(R^E - R)$, (2) The leverage ratio for financial intermediaries $\frac{NW^F}{QK}$, (3) the leverage ratio of entrepreneurs $\frac{NW^E}{QK}$, (4) the annualized default probability of financial intermediaries $F(\bar{\omega}^F_{ij})$, (5) the annualized default rate of entrepreneurs $F(\bar{\omega}_{ij}^E)$, (6) the spread between the FI 's loan rate and the FI 's borrowing rate $\left(Z^E - Z^F\right)$ and, finally, (7) the spread between the FI's borrowing rate and the risk free rate $\left(Z^F - R\right)$. I choose the value of parameters related to monitoring costs in the contract between banks and entrepreneurs (μ^E) and between banks and lenders (μ^F), volatility of the idiosyncratic shocks (σ^E, σ^F), steady state threshold productivity levels ($\bar{\omega}_H^E$, $\bar{\omega}_H^F$) and survival rate of entrepreneurs and financial intermediaries (γ^E, γ^F) to match the aforementioned steady state quantities.

In the calibration I assume that countries are fully symmetric, including in the degree of financial frictions, both within and between countries. This implies that domestic (foreign) financial intermediaries incur the same cost of monitoring domestic and foreign lenders, and domestic (foreign) lenders are subject to the same cost of monitoring domestic and foreign financial intermediaries. Furthermore, these costs are equalized across countries.

Given values of σ_F^E, σ_H^E and σ_H^F, σ_F^F, and a target value for the default probabilities in each sector $F(\bar{\omega}_H^E; \sigma_H^E), F(\bar{\omega}_F^E; \sigma_F^E)$ and $F(\bar{\omega}_H^F; \sigma_H^F), F(\bar{\omega}_F^F; \sigma_F^F)$, I can calculate the threshold productivity levels:

$$\bar{\omega}_{ij} = Ncdf^{-1}\left(\frac{\log \bar{\omega}_{ij} + 0.5\sigma^2}{\sigma}\right)$$

Now i can calculate the following quantities:

$$F'_\omega(\bar{\omega}_{ij}; \sigma_j^i) = f(\bar{\omega}_{ij}; \sigma_j^i) = \frac{1}{\bar{\omega}_{ij}\sigma_j^i} Npdf\left(\frac{\log \bar{\omega}_{ij} + 0.5\sigma_i^2}{\sigma_i}\right)$$

$$G(\bar{\omega}_{ij}; \sigma_j^i) = \int_0^{\bar{\omega}_{ij}} \omega_{ij} f(\bar{\omega}_{ij}) d\omega = Ncdf\left(\frac{\log \bar{\omega}_{ij} - 0.5\sigma^2}{\sigma}\right)$$

$$\Gamma(\bar{\omega}_{ij}; \sigma) = \bar{\omega}_{ij}\left(1 - F(\bar{\omega}_{ij}; \sigma)\right) + G(\bar{\omega}_{ij}; \sigma)$$

$$\Gamma'_\omega(\bar{\omega}_{ij}; \sigma) = 1 - F(\bar{\omega}_{ij})$$

$$G'_{\omega}(\bar{\omega}_{ij};\sigma)=\bar{\omega}_{ij}F'_{\omega}(\bar{\omega}_{ij};\sigma)$$

Given μ_j^i , I can calculate:

$$\Phi(\bar{\omega}_{ij};\sigma_j^i)=\Gamma(\bar{\omega}_{ij};\sigma)-\mu_{ij}G(\bar{\omega}_{ij};\sigma)$$

$$\Phi'_{\omega}(\bar{\omega}_{ij};\sigma)=\Gamma'_{\omega}(\bar{\omega}_{ij};\sigma)-\mu_{ij}G'_{\omega}(\bar{\omega}_{ij};\sigma)$$

Assume countries are symmetric, i.e. they have the same degree of financial frictions ($\sigma^E=\sigma^{E*}=\sigma^E$, $\sigma^F=\sigma^{F*}=\sigma^F$, $\mu^E=\mu^{E*}=\mu^E$, $\mu^F=\mu^{F*}=\mu^F$, $\bar{\omega}^E=\bar{\omega}^{E*}=\bar{\omega}^E$, $\bar{\omega}^F=\bar{\omega}^{F*}=\bar{\omega}^F$) and the same degree of openness ($\tau_H^F=\tau_F^F=\tau^F$, $\tau_H^E=\tau_F^E=\tau^E$).

Then from the first order conditions of the optimal contract in country H (recall that in steady state, $R_t=R_t^*=\frac{1}{\beta}$):

$$\begin{aligned}
&R_H^E\left[\left(1-\Gamma\left(\bar{\omega}^E\right)\right)\Phi'\left(\bar{\omega}^E\right)+\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^E\right)\right]\cdot\left[\left(1-\Gamma\left(\bar{\omega}^F\right)\right)(1-\tau^F)+\left(1-\Gamma\left(\bar{\omega}^F\right)\right)\tau^F\right]+\\
&(1-\tau^F)\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\left[\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^F\right)R_H^E\Phi\left(\bar{\omega}^E\right)+\Phi\left(\bar{\omega}^F\right)\Phi'\left(\bar{\omega}^E\right)\left(1-\Gamma\left(\bar{\omega}^E\right)\right)R_H^E\right]+\\
&\tau^F\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\left[\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^F\right)R_H^E\Phi\left(\bar{\omega}^E\right)+\Phi\left(\bar{\omega}^F\right)\Phi'\left(\bar{\omega}^E\right)\left(1-\Gamma\left(\bar{\omega}^E\right)\right)R_H^E\right]=\\
&=\frac{1}{\beta}(1-\tau^F)\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)+\frac{1}{\beta}\tau^F\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)
\end{aligned}$$

$$R_H^E\left\{\begin{array}{c}
\left[\left(1-\Gamma\left(\bar{\omega}^E\right)\right)\Phi'\left(\bar{\omega}^E\right)+\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^E\right)\right]\cdot\\
\left[\left(1-\Gamma\left(\bar{\omega}^F\right)\right)(1-\tau^F)+\left(1-\Gamma\left(\bar{\omega}^F\right)\right)\tau^F\right]+\\
\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Phi\left(\bar{\omega}^F\right)\Phi'\left(\bar{\omega}^E\right)\left(1-\Gamma\left(\bar{\omega}^E\right)\right)+\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^F\right)\Phi\left(\bar{\omega}^E\right)
\end{array}\right\}=$$

$$=R\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)$$

$$\frac{R_H^E}{R}=\frac{\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)}{\left\{\begin{array}{c}\left[\left(1-\Gamma\left(\bar{\omega}^E\right)\right)\Phi'\left(\bar{\omega}^E\right)+\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^E\right)\right]\cdot\\ \left[\left(1-\Gamma\left(\bar{\omega}^F\right)\right)\left(1-\tau^F\right)+\left(1-\Gamma\left(\bar{\omega}^F\right)\right)\tau^F\right]\\ +\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Phi\left(\bar{\omega}^F\right)\Phi'\left(\bar{\omega}^E\right)\left(1-\Gamma\left(\bar{\omega}^E\right)\right)+\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^F\right)\Phi\left(\bar{\omega}^E\right)\end{array}\right\}}$$

And,similarly:

$$\frac{R_F^E}{R}=\frac{\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)}{\left\{\begin{array}{c}\left[\Phi\left(\bar{\omega}^E\right)\Gamma'\left(\bar{\omega}^E\right)+\Phi'\left(\bar{\omega}^E\right)\left[1-\Gamma\left(\bar{\omega}^E\right)\right]\right]\cdot\\ \left[\left(1-\tau^F\right)\left[1-\Gamma\left(\bar{\omega}^F\right)\right]+\tau^F\left[1-\Gamma\left(\bar{\omega}^F\right)\right]\right]\\ +\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Phi'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^F\right)\left[1-\Gamma\left(\bar{\omega}^E\right)\right]+\frac{\Gamma'\left(\bar{\omega}^F\right)}{\Phi'\left(\bar{\omega}^F\right)}\Gamma'\left(\bar{\omega}^E\right)\Phi\left(\bar{\omega}^F\right)\Phi\left(\bar{\omega}^E\right)\end{array}\right\}}$$

Given symmetry, it results that:

$$\frac{R_H^E}{R}=\frac{R_H^{E*}}{R^*}=\frac{R_F^E}{R}=\frac{R_F^{E*}}{R^*}$$

Part. constraint entrepreneurs borrowing from FI H

$K=\left(1-\tau^E\right)K_H+\tau^E K_F$

$$\begin{aligned}\left[1-\Gamma\left(\bar{\omega}^E\right)\right]R_H^E Q K_H&=R_H^E NW^E\\ \frac{NW^E}{QK_H}&=\left[1-\Gamma_H^E\left(\bar{\omega}^E\right)\right]\end{aligned}\tag{60}$$

$$\begin{aligned}\left[1-\Gamma\left(\bar{\omega}^E\right)\right]R_H^{E*}Q^*K_H^*&=R_H^{E*}NW^{E*}\\ \frac{NW^{E*}}{Q^*K_H^*}&=\left[1-\Gamma\left(\bar{\omega}^E\right)\right]\end{aligned}\tag{61}$$

Part. constraint entrepreneurs borrowing from FI F:

$K_t^*=\tau^E K_{H,t}^*+\left(1-\tau^E\right)K_{F,t}^*$

$$\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right] R_{F}^{E} Q K_{F}=R_{F}^{E} N W^{E} \tag{62}$$
$$\frac{N W^{E}}{Q K_{F}}=\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]$$

$$\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right] R_{F}^{E*} Q^{*} K_{F}^{*}=R_{F}^{E*} N W^{E*} \tag{63}$$
$$\frac{N W^{E*}}{Q^{*} K_{F}^{*}}=\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]$$

From previous 4 equations + definition of aggregate capital I get:

$$\frac{N W^{E}}{Q K}=\left[\frac{\tau^{E}}{\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]}+\frac{\left(1-\tau^{E}\right)}{\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]}\right]^{-1}=\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]$$
$$\frac{N W^{E*}}{Q^{*} K^{*}}=\left[\frac{\tau^{E}}{\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]}+\frac{\left(1-\tau^{E}\right)}{\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]}\right]^{-1}=\left[1-\Gamma\left(\bar{\omega}^{E}\right)\right]$$

Part constraints lenders to FI H:

$$(1-\tau^{F}) R^{F}\left[\left(1-\tau^{E}\right)\left(Q K_{H}-N W^{E}\right)+\tau^{E}\left(Q^{*} K_{H}^{*}-N W^{E*}\right)\right] \cdot \Phi\left(\bar{\omega}^{F}\right) \tag{64}$$
$$=R(1-\tau^{F})\left[\left(1-\tau^{E}\right)\left(Q K_{H}-N W^{E}\right)+\tau^{E}\left(Q^{*} K_{H}^{*}-N W^{E*}\right)-N W^{F}\right]$$

$$\tau^{F} R^{F}\left[\left(1-\tau^{E}\right)\left(Q_{t} K_{H}-N W^{E}\right)+\tau^{E}\left(Q^{*} K_{H,t}^{*}-N W^{E*}\right)\right] \cdot \Phi\left(\bar{\omega}^{F}\right)$$
$$=R^{*} \tau^{F}\left[\left(1-\tau^{E}\right)\left(Q K_{H}-N W^{E}\right)+\tau^{E}\left(Q^{*} K_{H}^{*}-N W^{E*}\right)-N W^{F}\right] \tag{65}$$

The two expressions are equivalent in steady state as $R=R^{*}$. Furthermore, if countries are symmetric: $QK_H = Q^*K_H^* = QK$ and $NW^E = NW^{E*}$ so that:

$$-\frac{R^F}{R}\left(QK - NW^E\right)\cdot\Phi\left(\bar{\omega}^F\right) + \left(QK - NW^E\right) = NW^F$$

$$\left(QK - NW^E\right)\left[1 - \frac{R^F}{R}\cdot\Phi\left(\bar{\omega}^F\right)\right] = NW^F \tag{66}$$

$$\left(1 - \frac{NW^E}{QK}\right)\left[1 - \frac{R^F}{R}\cdot\Phi\left(\bar{\omega}^F\right)\right] = \frac{NW^F}{QK} \tag{67}$$

Part constraint FI H:

$$\begin{aligned}&\left[\left(1-\tau^E\right)R_H^E QK_H\Phi\left(\bar{\omega}^E\right) + \tau^E R_H^{E*}Q^*K_H^*\Phi\left(\bar{\omega}^E\right)\right] = \\ &= R^F\left[\left(1-\tau^E\right)\left(QK_H - NW^E\right) + \tau^E\left(Q^*K_H^* - NW^{E*}\right)\right]\end{aligned} \tag{68}$$

Again imposing symmetry:

$$\frac{\Phi\left(\bar{\omega}^E\right)}{\left(1 - \frac{NW^E}{QK_H}\right)} = \frac{R^F}{R^E}$$

Similarly for foreign financial intermediaries:

Part constraint lenders to FI F:

$$\begin{aligned}&\tau^F R^{F*}\left[\tau^E\left(QK_F - NW^E\right) + (1-\tau^E)\left(Q^*K_F^* - NW^{E*}\right)\right]\Phi^F\left(\bar{\omega}^F\right) \\ &= R\tau^F\left[\tau^E\left(QK_F - NW^E\right) + (1-\tau^E)\left(Q^*K_F^* - NW^{E*}\right) - NW^{F*}\right]\end{aligned} \tag{69}$$

$$\begin{aligned}&(1-\tau^F)R^{F*}\left[\tau^E\left(QK_F - NW^E\right) + (1-\tau^E)\left(Q^*K_F^* - NW^{E*}\right)\right]\Phi^F\left(\bar{\omega}^F\right) \\ &= R^*(1-\tau^F)\left[\tau^E\left(QK_F - NW^E\right) + (1-\tau_F^E)\left(Q^*K_F^* - NW^{E*}\right) - NW^{F*}\right]\end{aligned} \tag{70}$$

So that:

$$\left(1 - \frac{NW^{E*}}{Q^*K^*}\right)\left[1 - \frac{R^{F*}}{R^*}\Phi^F\left(\bar{\omega}^F\right)\right] = \frac{NW^{F*}}{Q^*K^*}$$

Where $\frac{R^{F*}}{R^{*}}$ can be derived from the participation constraint of foreign FIs:

$$\frac{\Phi\left(\bar{\omega}^{E}\right)}{\left(1-\frac{NW^{E*}}{Q^{*}K^{*}}\right)}=\frac{R^{F*}}{R^{E}}$$

Finally, using the default threshold definitions (equations (5.48) and (5.49)) I can compute the steady state loan rate to entrepreneurs and to financial intermediaries (interbank rate):

$$Z^{E}=Z_{H}^{E}=Z_{F}^{E*}=Z_{F}^{E}=Z_{F}^{E*}=\frac{\bar{\omega}^{E}R^{E}}{\left(1-\frac{NW^{E}}{QK}\right)}$$

$$\bar{\omega}_{H}^{F}R^{F}\left(QK-NW^{E}\right)=Z_{H}^{F}\left[\left(QK-NW^{E}\right)-NW^{F}\right]$$

$$Z^{F}=Z_{H}^{F}=Z_{H}^{F*}=Z_{F}^{F}=Z_{F}^{F*}=\frac{\bar{\omega}_{H}^{F}R^{F}\left(1-\frac{NW^{E}}{QK}\right)}{\left[\left(1-\frac{NW^{E}}{QK}\right)-\frac{NW^{F}}{QK}\right]}$$

Given the steady state values for the financial side of the model, I can solve for variables pertaining to the real sector.

Real side of the model

Given R^{E}, I can use equation (5.37) to compute r^{K}:

$$r^{K}=R^{E}-(1-\delta)$$

$$MC_{H}=\frac{\varepsilon_{H}-1}{\varepsilon_{H}}$$

$$\Delta_{H}=\Delta_{H}^{*}=1$$

$$\frac{K}{Y}=\frac{\alpha MC}{r^{K}}$$

$$\frac{K}{H} = \left(\frac{K}{Y}\right)^{\frac{1}{1-\alpha}}$$

$$W = (1-\alpha)\, MC \left(\frac{K}{H}\right)^{\alpha}$$

Fix $H = 0.33$, and solve for K :

$$K = \frac{K}{H} H$$

$$Y = \left(\frac{K}{Y}\right)^{-1} K$$

And then calculate:

$$I = \delta K$$

$$NW^E = \left(\frac{NW^E}{QK}\right) K$$

$$NW^F = \left(\frac{NW^F}{QK}\right) K$$

$$V^E = \left[1 - \Gamma^E\left(\bar{\omega}^E\right)\right] R^E QK$$

$$V^F = \left[1 - \Gamma^F\left(\bar{\omega}^F\right)\right] R^F\left(QK - NW^E\right)$$

Then I can back out γ^E and γ^F:

$$\begin{aligned}
\gamma^E &= \frac{(NW^E - (1-\alpha)\Omega_E \cdot MC \cdot Y_H)}{V^E} \\
\gamma^F &= \frac{(NW^F - (1-\alpha)\Omega_F \cdot MC \cdot Y_H)}{V^F}
\end{aligned}$$

$$C^E = \left(1-\gamma^E\right)\left[1-\Gamma^E\left(\bar{\omega}^E\right)\right] R^E QK$$
$$C^F = \left(1-\gamma^F\right)\left[1-\Gamma^F\left(\bar{\omega}^F\right)\right] R^F \left(QK - NW^E\right)$$

Steady state monitoring costs incurred by entrepreneurs and FIs are given by:

$$M = \mu^E G\left(\bar{\omega}^E\right) R^E QK + \mu^F G\left(\bar{\omega}^F\right) R^F \left(QK - NW^E\right)$$

Now use the goods market clearing conditions for the Home and Foreign countries to solve for the steady state Home and Foreign consumption:

$$C_F = \frac{1}{\left[(1-\gamma^*) - \frac{(1-\gamma)\gamma^*}{\gamma}\right]} \left\{ \begin{array}{c} Y_F - (1-\gamma^*)\left(I_F + C_F^E + C_F^F\right) - \\ (1-\gamma)\frac{n}{(1-n)}\left(I_H + C_H^E + C_H^F\right) - G_F - M_F \\ -\frac{n}{(1-n)}\frac{(1-\gamma)}{\gamma}\left[\begin{array}{c} Y_H - G_H - \gamma\left(I_H + C_H^E + C_H^F\right) - \\ M_H - \gamma^* \frac{(1-n)}{n}\left(I_F + C_F^E + C_F^F\right) \end{array}\right] \end{array} \right\}$$

$$C_H = \frac{1}{\gamma}\left[Y_H - \gamma I_H - G_H - \gamma^* \frac{(1-n)}{n}\left(C_F + I_F + C_F^E + C_F^F\right) - \gamma C_H^E - M_H - \gamma C_H^F\right]$$

Now I can solve for the remaining variables:

$$\begin{aligned} K^p &= MC \frac{Y_H}{(1-\beta\theta_H)} \\ F^p &= \frac{Y_H}{(1-\beta\theta_H)} \\ \tilde{P}_H &= \frac{\varepsilon_H}{\varepsilon_H - 1}\frac{K^p}{F^p} \end{aligned}$$

$$\mu = \frac{1}{C_H(1-h)}$$

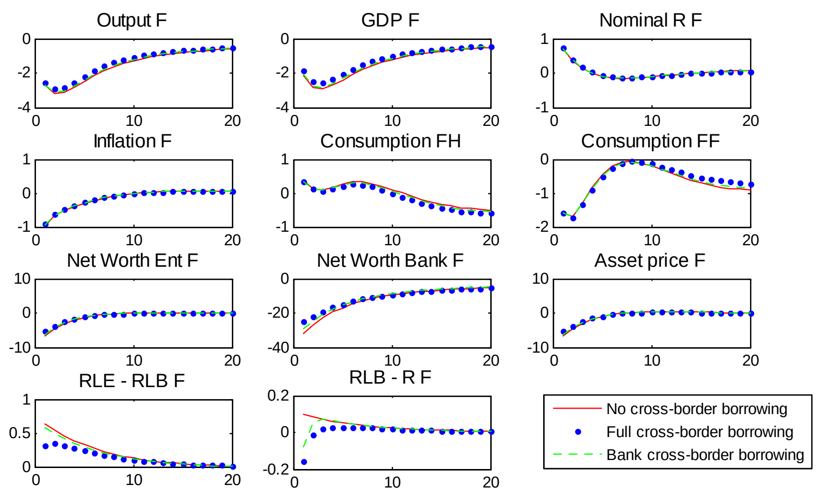
$$\chi_H = \frac{\varepsilon_w - 1}{\varepsilon_w}\frac{\mu}{H^\varphi}\frac{W}{P}$$

$$\begin{aligned}
K^{w} &= \frac{\varepsilon_w - 1}{\varepsilon_w} \frac{HW\mu}{(1-\beta\theta_w)} \\
F^{w} &= \frac{\chi_H H^{\varphi}}{(1-\beta\theta_w)} \\
\tilde{W} &= W
\end{aligned}$$

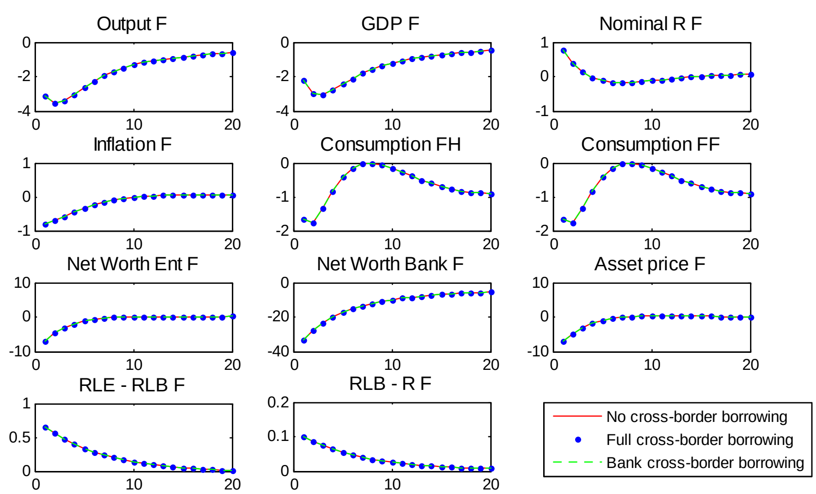
5.A.5 Impulse-responses in the Foreign country

Figure 5.9: Responses of Foreign country to a 1 percent foreign interest rate shock

Flexible exchange rate in H country



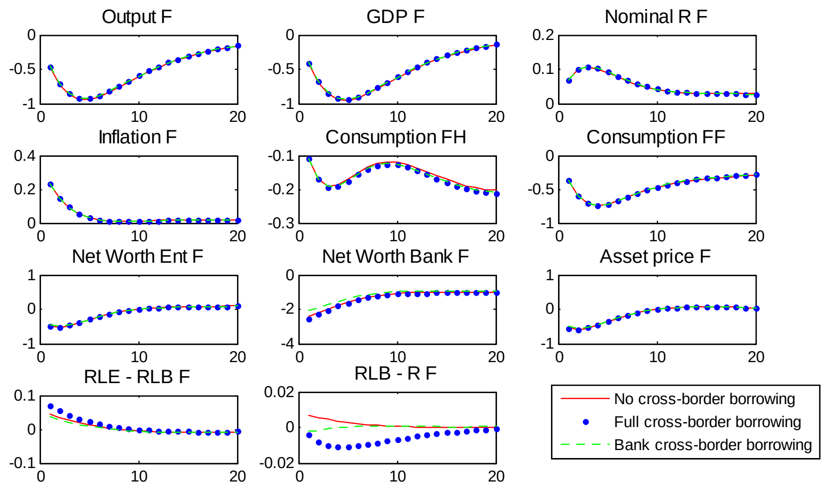
Fixed exchange rate in H country



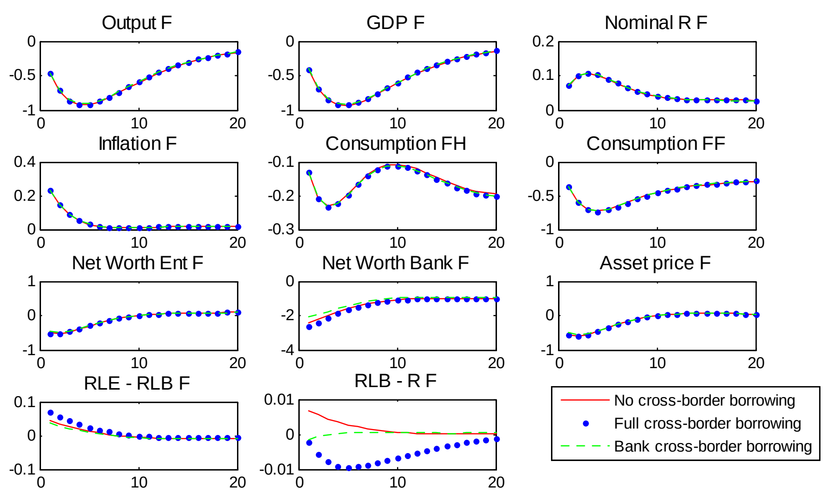
Note: Responses are represented in percentage deviations from the steady state

Figure 5.10: Responses of Foreign country to a 1 percent productivity shock

Flexible exchange rate in H country



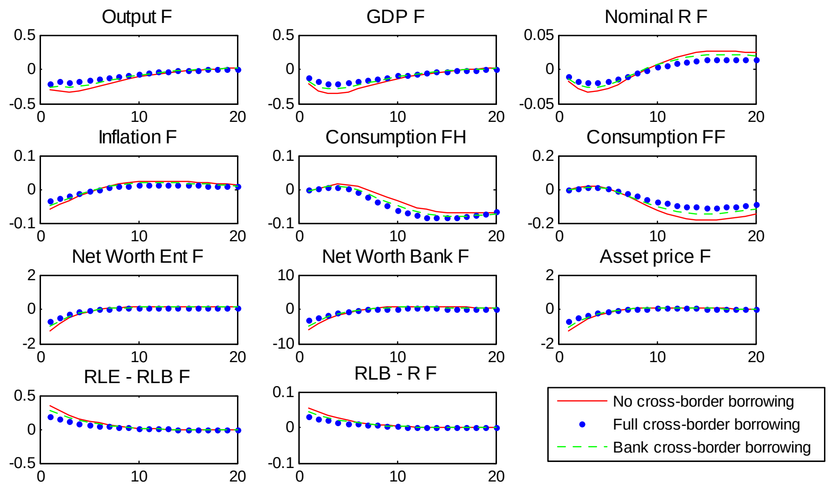
Fixed exchange rate in H country



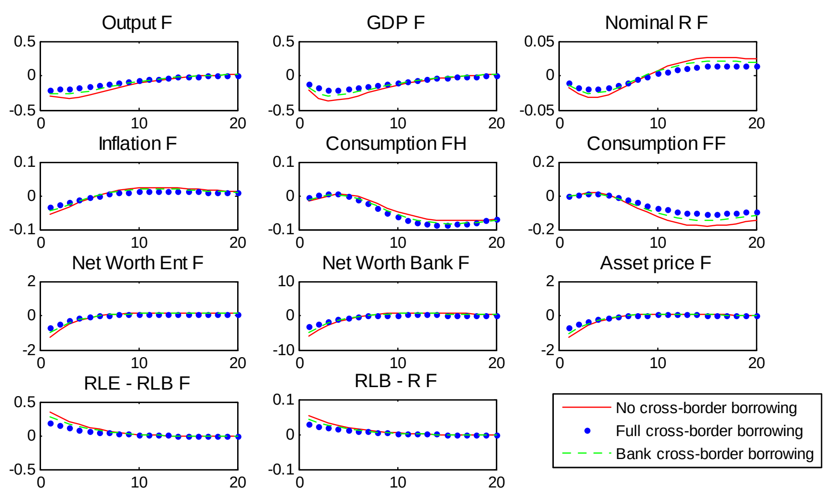
Note: Responses are represented in percentage deviations from the steady state

Figure 5.11: Responses of Foreign country to a 1 percent σ_F shock

Flexible exchange rate in H country



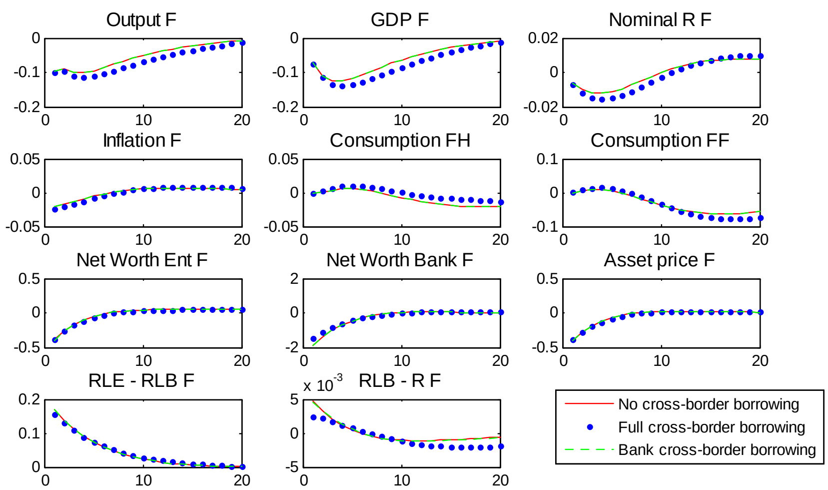
Fixed exchange rate in H country



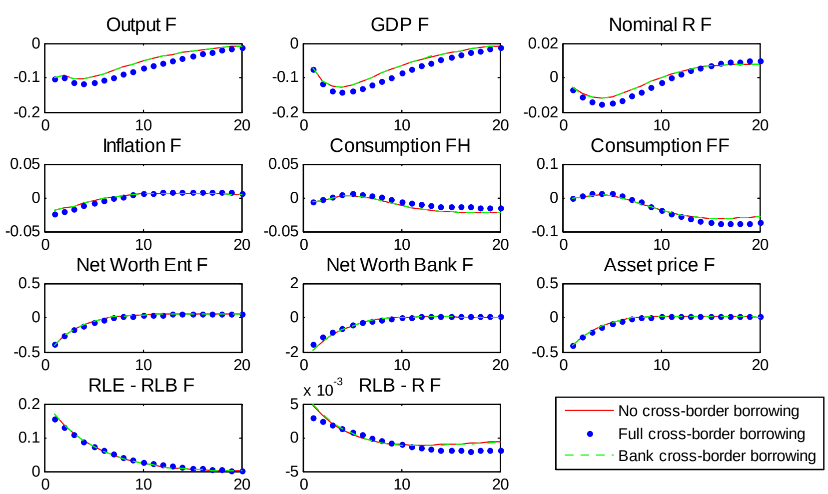
Note: Responses are represented in percentage deviations from the steady state

Figure 5.12: Responses of Foreign country to a 1 percent σ_E shock

Flexible exchange rate in H country



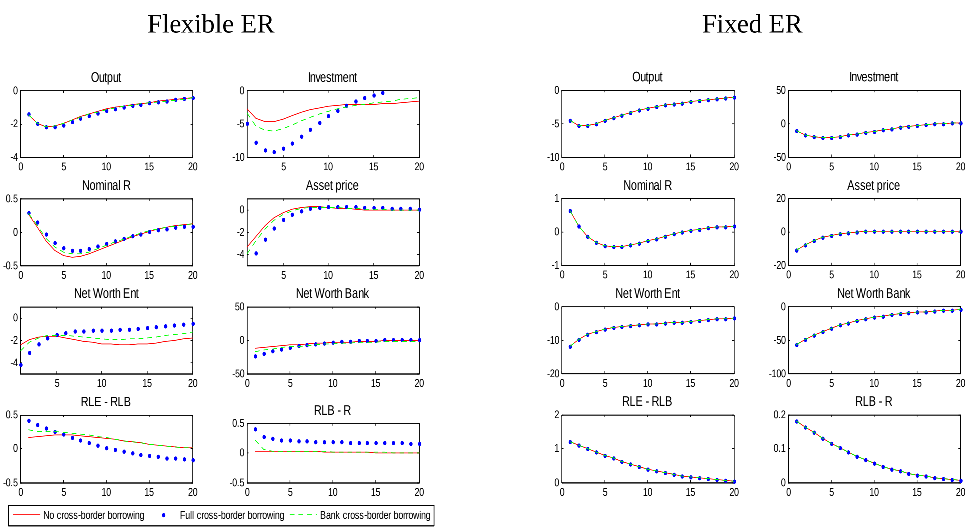
Fixed exchange rate in H country



Note: Responses are represented in percentage deviations from the steady state

5.A.6 Impulse responses: nominal credit contract

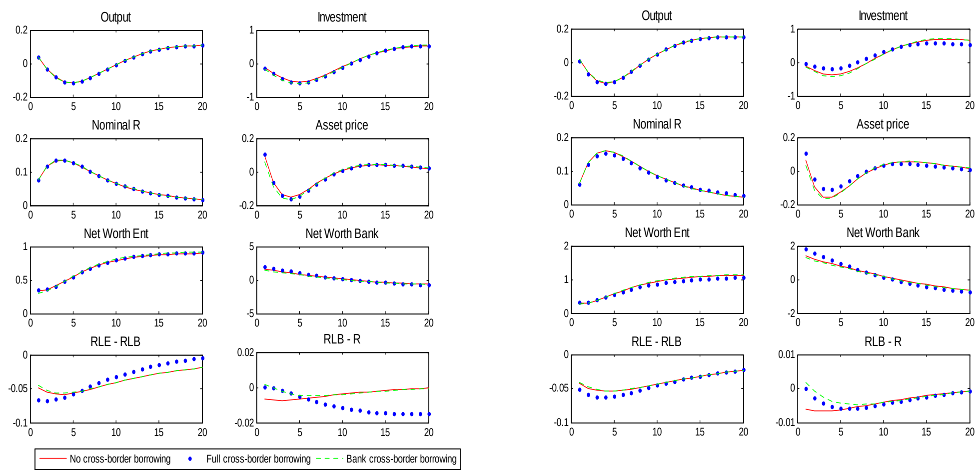
Figure 5.13: Responses to a 1 percent foreign interest rate shock



Note: Responses are represented in percentage deviations from the steady state

Figure 5.14: Responses to a 1 percent foreign interest rate shock

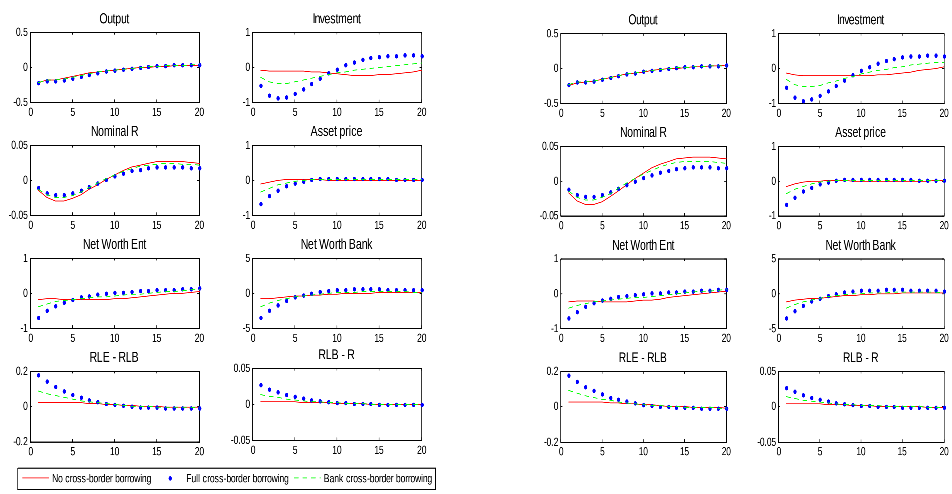
Flexible ER Fixed ER



Note: Responses are represented in percentage deviations from the steady state

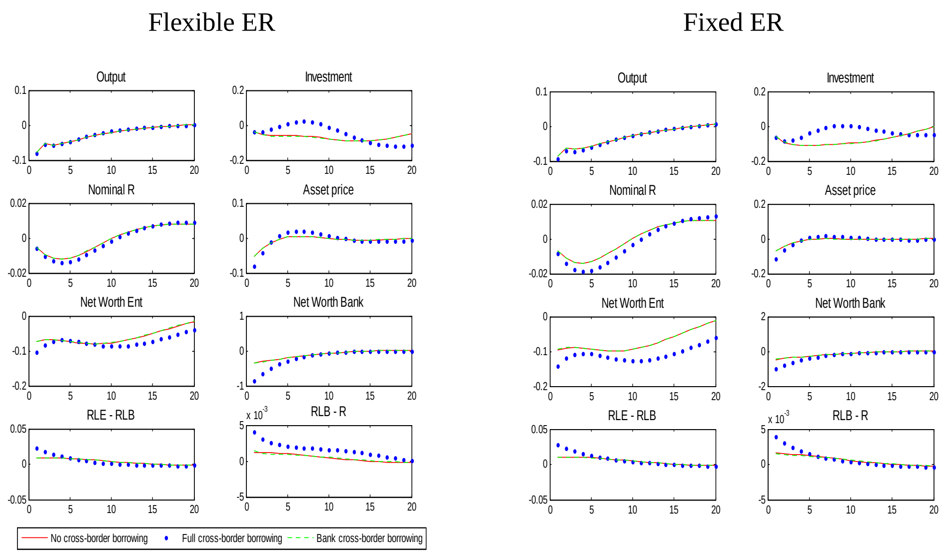
Figure 5.15: Responses to a 1 percent foreign interest rate shock

Flexible ER Fixed ER



Note: Responses are represented in percentage deviations from the steady state

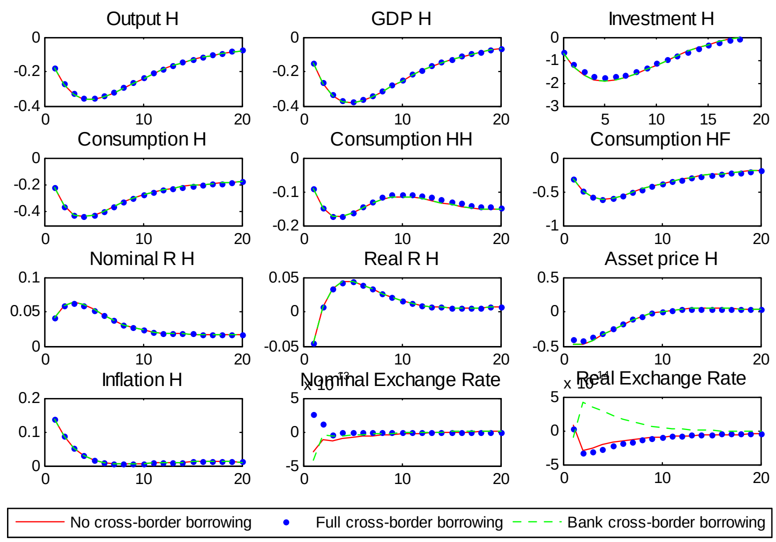
Figure 5.16: Responses to a 1 percent foreign interest rate shock



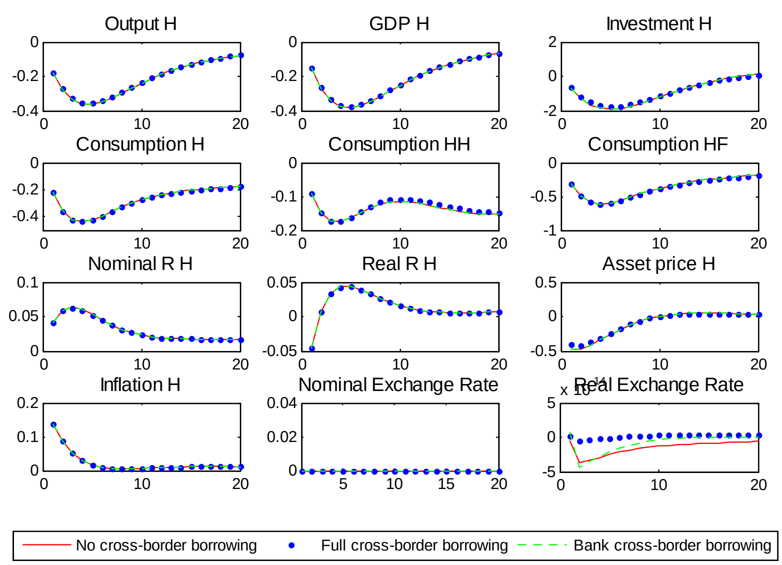
Note: Responses are represented in percentage deviations from the steady state

Figure 5.17: Responses of Home country to a 1 percent foreign productivity shock: $n = 0.5, \lambda = 0.8$

Flexible exchange rate



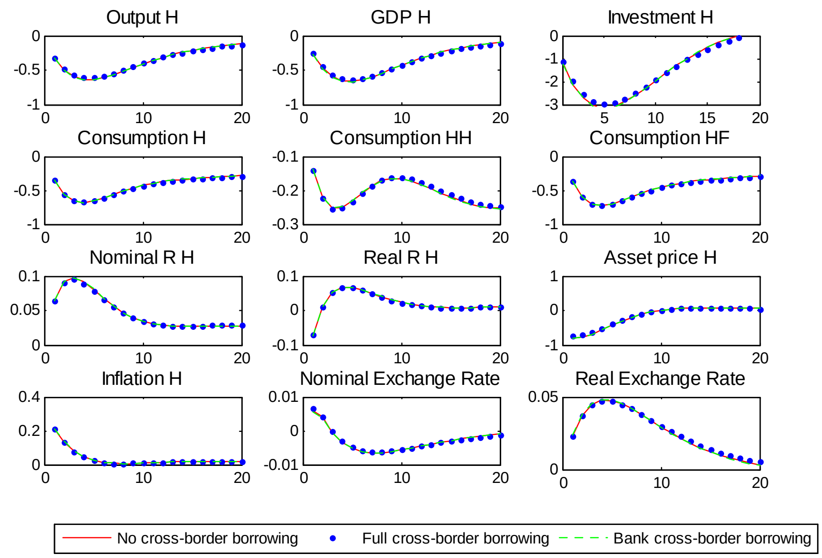
Fixed exchange rate



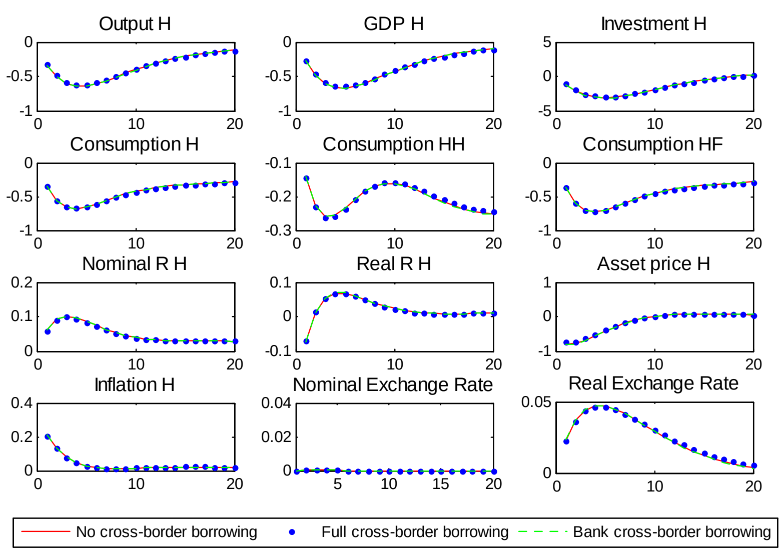
Note: Responses are represented in percentage deviations from the steady state

Figure 5.18: Responses of Home country to a 1 percent foreign productivity shock: $n - 0, \lambda = 0.1$

Flexible ER



Fixed ER



Note: Responses are represented in percentage deviations from the steady state

CHAPTER 6
CONCLUSIONS

This dissertation has explored several issues related to monetary policy in small open economies, taking as reference the experience of the new EU member states of Central and Eastern Europe. During the transition process, these countries became more and more integrated with Western Europe, and benefited from large capital inflows from this region as well as increased trade flows. On one side, tighter trade and financial integration led Eastern European economies to be increasingly influenced by Western european developents. On the other hand, the availability of cheap capital flowing from the West enabled them to increase their consumption and investment beyond levels that would have been achieved using internal savings only. Rapid credit growth was directed to both households and firms, and loans were granted, in large part, in foreign currency. In this dissertation, I analysed three aspects of the interplay between monetary policy and economic and financial openness, which can be of useful input for policymaking in small open economies sharing similar characteristics.

The first essay focussed on the interplay between stock prices and monetary policy (both domestic and Euro Area) in four NMS. The results reveal that in these economies stock prices are more influenced by Euro Area, rather than domestic, monetary policy shocks. The results reveal that, while domestic monetary policy shocks do not exert a significant impact on stock prices, unexpected changes in Euro Area monetary policy do. Specifically, a contraction in foreign monetary policy reduces stock prices in the NMS. Furthermore, variables associated with international finance and trade (namely the exchange rate and the foreign interest rate) are the main determinants of the variability of stock prices in the considered countries. This seems to suggest that in small economies characterized by a high degree of openness, stock markets are more sensitive to shocks related to international trade and finance.

Chapters 4 and 5 adopt a more theoretical standpoint, modeling the salient characteristics of the CEECs in a DSGE framework and modeling frictions on credit markets embracing the financial accelerator framework of Bernanke, Gertler and Gilchrist (1999). Both essays examine the conduct of monetary policy in response to real and financial shocks, but from different points of view. While chapter 4 focusses on a booming phase, where capital inflows fuel domestic credit growth to households and firms characterized by liability dollarization, chapter 5 studies the isolating properties of fixed and flexible exchange rate regimes in a small open economy engaging in cross-border borrowing and lending. In both cases, results are consistent with the existing literature, affirming the inferiority of a fixed exchange rate regime as a monetary policy strategy. More specifically, chapter 4 concludes that small open economies pegging the exchange rate are characterized by a more marked macro-financial overheating following capital inflow shocks, reflected in a greater credit growth and expansion of aggregate demand, and a stronger increase in inflation. Furthermore, I find that in the case the monetary authority is not concerned with financial stability, steering the interest rate responding only to inflation and output deviations (i.e. following a standard Taylor rule) is optimal. Adding financial stability to the central bank's objectives does not result in an optimal reaction to credit growth, while some degree of reaction to exchange rate depreciation is optimal. In fact, reacting to credit growth implies a too sharp tightening of monetary policy in response to capital inflow shocks, which results in further exchange rate appreciation and further strengthens borrowers' balance sheet encouraging more foreign borrowing. This seems to suggest that in a small open and dollarized economy, a the central bank with financial stability objectives but equipped with one instrument, namely the nominal interest rate, cannot simultaneously achieve macroeconomic and financial stability. Finally, chapter 5 confirms the superiority of a flexible exchange rate regime in stabilizing the economy facing adverse foreign shocks. Furthermore, a flexible exchange rate regime ranks higher from the perspective of both the small open economy's central bank and households' welfare. From the point of view of the small open economy's monetary authority, the relative cost of pegging the currency increases the larger its concerns for financial stability, since it involves a stronger monetary policy reaction to preserve the parity, which has repercussions on the volatility of financial variables. On the other hand, tighter cross-border lending relationships decrease the relative cost of pursuing a fixed exchange rate strategy.

This thesis offers a twofold contribution to the existing literature. First, it sheds light on three different issues related to monetary policy and its interaction with financial variables in small open economies. Secondly, the analysis in the last two chapters is performed considering specific characteristics of Eastern European small open economies and fitting them in state-of-the-art macroeconomic models featuring a prominent role of credit market imperfections.

While being the end of a journey, this dissertation marks the starting point for new ideas and projects, now that the relationship between monetary policy and financial linkages is, hopefully, clearer.

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